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PREFACE.

THE Sixth Indian Science Congress met at Bombay in January 1919. The Agricultural Section was presided over by the Hon'ble Mr. G. F. Keatinge, C.I.E., I.C.S., and this special issue of the *Agricultural Journal of India* contains a selection of the papers bearing on agriculture and allied subjects read at the Congress. It is impossible to publish all the papers read on account of limitation of space in this issue, but the following papers will be published in the ordinary issues of the *Agricultural Journal of India* :—

(1) The Frequent Failure of a large Proportion of the Rice crop in Chota Nagpur, by A. C. Dobbs.

(2) Note on Land Drainage in Irrigated Tracts of the Bombay Deccan, by C. C. Inglis.

(3) The Importance of the Development of the Dairy Industry in India, by W. Smith.

(4) The Improvement of Indian Dairy Cattle, by A. K. Yegnanarayan Iyer.

(5) The Prevention of Soil Erosion on Tea Estates in Southern India, by R. D. Anstead.

(6) The Fragmentation of Holdings as it affects the Introduction of Agricultural Improvements, by B. C. Burt.

(7) Results of Further Experiments and Improvements in the Method of Planting Sugarcane and Further Study of the Position of Seed in the Ground while Planting, by M. L. Kulkarni.

The paper on "Nitrogenous Fertilizers : Their Use in India," by C. M. Hutchinson, has already appeared in the *Agricultural Journal of India*, Vol. XIV, Pt. II, 1919, while that on "The Use of Poppy Seed Cake as a Cattle Food and its Effects on Yield of Milk and Composition of the Butter Fat," by H. E. Annett and J. Sen, will probably be published either in the *Journal of Agricultural Science* or in the *Analyst*.

I am indebted to His Excellency Sir George Lloyd, the Patron of the Congress, for kindly allowing his photograph to be inserted as a frontispiece to this Number, while my acknowledgments are also due to the Asiatic Society of Bengal, under whose auspices the Indian Science Congress is held, for their kindness in allowing us to publish the papers contained in this issue *in extenso.*

G. A. D. STUART,

Offg. Agricultural Adviser to the Govt. of India.

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HIS EXCELLENCY SIR GEORGE LLOYD, G.C.I.E.,
GOVERNOR OF BOMBAY.

ECONOMIC FACTORS OF AGRICULTURAL PROGRESS.*

BY

THE HON'BLE MR. G. F. KEATINGE, C.I.E.,

Lately Director of Agriculture, Bombay.

TLEMEN,

IT is my pleasing duty to welcome you here to this session of Agriculture and Applied Botany Section. We have before us nty papers on a variety of subjects connected with agriculture, I have no doubt that we shall have some very interesting ussions on these papers.

I much appreciate the compliment that has been paid to me in ing me to preside over this Section of the Science Congress, more so since I cannot claim to be a scientific investigator. ing the past 25 years, however, I have had occasion, first as a enue officer and then as an agricultural officer, to study the nomic condition of the cultivators in this Presidency, and I pose to address you on some economic factors which I conceive to of fundamental importance in the matter of agricultural progress. itical Economy has, I believe, been described as the "dismal nce." I fear that you may find my remarks dismal, but I hope you will not find them unscientific. My excuse for addressing on a subject somewhat remote from physical science is that I k that all you agricultural workers in this country, whether are agriculturists, chemists, botanists or engineers, are often pelled to realize that the results of your labours, the practical lication of the methods which you advocate, are largely discount- and severely handicapped by existing economic difficulties.

* Presidential address delivered before the Agricultural Section of the Indian Science ress, Bombay, January, 1919.

You discover something which should be of great value to t community, but the economic condition is often such that har any one is in a position to take advantage of your discovery. T cannot fail to be very disheartening to yourselves, to the pub which is looking for material advancement at your hands, and the Governments to whom we have to look for increased suppo If the existing economic difficulties were insuperable, there wo be little use in railing against them ; but it is because I believe t they can be overcome and that a situation can be created in whi the practical value of your labours can be greatly increased, tha venture to address you on the subject.

Stated in its briefest possible form, my proposition is this. farming there are two fundamental units, the farm and the farm For agricultural progress it is necessary that the farm should be fixed and permanent unit, so that it may admit of permanent i provement and adequate development, and that the farmer shou be a fluid and moveable unit, so that the right men may get to t right places. Speaking generally, we find, to our misfortune, th in India the exact reverse is the case, that the farm, on the one han is subject to a continuous series of economic earthquakes, and th the farmer, on the other hand, is fixed and rooted.

To turn first to the farm. So much has been said during t last few years on the subject of the subdivision and fragmentati of holdings, and the evil has been so generally recognized, that do not propose to go into the matter in any detail. No orderly dev lopment, no effective improvement can take place in a holding whi is the wrong size and shape and which has no stability. The fa that this is true not only in theory but also in practice can be verifi by any one who will take the trouble to do so. Not only is t land totally undeveloped, as development is known in other cou tries, but the idea of progressive development is hardly understoo by the landowners. To develop and improve a permanent 10- 20-acre farm is an intelligible proposition ; but to develop an improve a 10- or 20-acre farm which must in the near future be spl up and fragmented is not an intelligible proposition to any one and since this is the proposition which confronts the Indian farm

is not ... prising that he does not consider it seriously. In this y a low standard is set of agricultural methods and of agricultural ults, a serious obstruction to progress is presented, and there ses a generally uneconomic situation which tends to become rse rather than better.

Now let us turn to the farmer. The farmer owns his small d fluctuating area of land, it may be 15 acres of land in three ts in one generation, and 5 acres in six plots in the next generation. e point is that the farmer is fixed and permanent. His farm y fly into fragments and grow steadily smaller, but, generally aking, he himself persists, whether he be a good, bad or indifferent mer. In highly individualistic and competitive countries, iciency is secured largely by the elimination of the unfit, who are eezed out of the race by keen competition coupled by a high ndard of living. This law is in constant operation in England, d there have been periods of agricultural depression there, when progressive farmers have been ruined and squeezed out whole- e, while on some kinds of soil it is recognized that a bad farmer not hope, even in prosperous times, to survive many seasons. rural India, however, the competition is less keen, the standard living lower, and an easy-going tolerance, combined with an stic joint-family system, helps to tide the less effective members r their difficulties and to keep them in their places to the obstruc- n of the more effective members of the community. It is by no ans contended that there are no good farmers, nor can it be pected anywhere that all farmers will reach a high degree of ellence; all that is suggested is that, owing to the causes mention- above, the proportion of bad and indifferent farmers is unduly ge. And after all it is this proportion which counts; for while would term a country backward in agriculture in which only per cent. of the farmers were good farmers, we would be able class it as advanced in agriculture if 50 per cent. of the farmers re advanced and progressive.

We may then sum up the situation thus—

The majority of the farms are of the wrong size and the wrong ape, they are not permanent units and are not susceptible of

orderly and adequate improvement. The majority of the farm are deficient in skill, industry and energy, and balance a low standa of endeavour by a low standard of living.

These are the fundamental obstructions to agricultural progre to which I have to refer. The question is how we are to overco them. It is clear that what we have to do is to endeavour to crea and maintain suitably sized and suitably situated holdings whi will admit of adequate development, and to arrange that the shall be nothing to prevent these economic units from passing natural laws into the hands of the most progressive farmers w will be in a position to make the best use of them. If we can this we can trust to the natural fertility of the soil and the natur industry of the farmers to secure the progress which we desi aided by the scientific investigations which have been made ar which will be made in future. But until we can do this we shall n secure anything like the full results that we look for from our natur advantages or from our scientific labours.

Now what is it that prevents us from taking action of th nature indicated? Whenever any remedial action of this nature suggested it is always urged that the people have not asked for suc action and do not want it, that such action would be opposed t their religion and to their sentiments, and that a shuffle of farm and of farmers would constitute a political danger. These aspect of the question must, of course, be carefully considered. This is country where religious and sentimental ideals count for much where political dangers must be given due weight. But there i also a persistent demand on the part of a section of the populatio for material progress. We have come to the parting of the ways and India must decide which road she wishes to take. You may set up a sentimental ideal, an æsthetic ideal, an ideal of voluntary poverty, or an ideal of political caution. Such ideals are quite intelligible. The trouble is that to a large extent they are not compatible with the ideal of material progress. All that I say is this: if the former ideals are chosen to the exclusion of the latter let us stop all talk of rapid material progress; for we shall have deliberately refused to take the first steps that lead to it.

[D]RAINAGE AND CROP PRODUCTION IN INDIA.

BY

[A]LBERT HOWARD, C.I.E.,
[I]mperial Economic Botanist,

AND

GABRIELLE L. C. HOWARD, M.A.,
Second Imperial Economic Botanist.

[T]HE present may be described as the era of reconstruction. [...]s which were current five years ago have since been proved [obs]olete. Agriculture, which is concerned with the production [of f]ood and of raw materials, is now recognized as one of the key [indu]stries of the modern world whose development must be fostered [by] all the resources of the State. One of the main problems before [the] Indian Agricultural Department is the discovery of the best [mea]ns of making the soil yield a higher dividend. This involves [the] recognition of the factors which limit production over large [area]s and the discovery of the best way of putting them out of opera[tion]. One of these limiting factors is defective soil-aeration. At [the] Lahore meeting of the Indian Science Congress, one of the [subj]ects discussed was the aeration of the soil and its bearing on flood [irri]gation in the arid regions of North-West India.[1] It was shown [tha]t successful irrigation involves more than the mere application [of w]ater and that the aim of the irrigator should be *the provision of [wat]er in such a manner as to interfere as little as possible with the [aera]tion of the soil.* The present paper attempts to deal with another [asp]ect of soil-aeration, namely, inadequate drainage—a matter of [par]ticular importance in many parts of India. Over large areas [nou]rished by the monsoon, this factor bars progress. Its removal, [how]ever, is a matter which often lies outside the scope of the

[1] [R]ecent investigations on soil-aeration. *Agric. Journ. of India*, vol. XIII, 1918, p. 416.

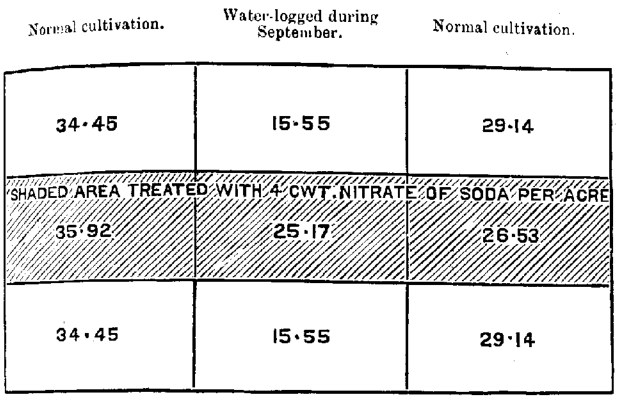
Agricultural Department and its mere consideration involves multitude of other interests—those of the cultivator, the landown the revenue authorities, the engineer and the sanitarian. As t years pass, we are more and more impressed with the importa of drainage in the agricultural development of India and the pres opportunity is taken of bringing the subject forward once more. T connection between drainage and soil-aeration is not always clea recognized. The essence of drainage, from the plant's point of vie is the maintenance of the oxygen supply of the soil water. the case of ordinary dry crops like wheat, all that is necessa to bring this about is an adequate gaseous exchange between atmosphere and the pore-spaces. In water culture, of which rice perhaps the best agricultural example, it is essential that th should be a very slow movement of oxygenated water round feeding roots. Sometimes, when the country is flooded, dry cr have to change over for a time to water culture. As long the flood water is in movement and the aeration of the roots provided for, little or no damage results.

In the plains of India, defective drainage arises during monsoon from two distinct causes. In the first place, where soils are on the stiff side, local surface accumulations of rain-wa rapidly lower the fertility. In the second place, the sub-soil wa often rises to such an extent at a time when the flow of the rivers impeded that little or no general drainage is possible over la tracts of the alluvium. These two aspects of the subject will considered separately.

Surface Water-logging.

On the stiffer loams of the Gangetic alluvium, local unevenness in the crops are very common. Any partial holding up of t surface drainage by irrigation channels and any slight concavi of the fields, due to depressions or to the misuse of iron ploug are invariably followed by poor weak growth which exhibits all t characteristics of nitrogen starvation. That the loss of fertility largely due to denitrification is proved by the results of an expe ment carried out at Pusa in 1910. In that year, a plot of heat

nd was purposely water-logged during the month of September order to compare its behaviour with normally managed land on her side. Across the middle of the plots a strip was manured th 4 cwt. of nitrate of soda to the acre just before sowing the eat. The results are given in Fig. 1, from which it will be seen that effect of a month's water-logging was to reduce the yield of wheat about 16 bushels to the acre.



The numbers in the plan are bushels per acre.

FIG. 1. The result of water-logging wheat land at Pusa in 1910.

In another case at Pusa, a portion of a rather stiff piece of land is similarly water-logged during September 1917 and sown with va indigo the following month. The effect of the water-logging this leguminous crop was very marked. Five months after wing, equal areas on the water-logged and control plots were taken d the heights of the plants were measured. On the water-logged ot, the average height of 200 plants was 10·4 cm., on the control e average height of an equal number of plants was 28·0 cm. When e root-system of the plants on these plots was examined it was und that the first effect of water-logging was to restrict the roots the upper layers during the first few months of growth and to ange the general character of the root-system. The results are own in Fig. 2. On the left is represented the root-system of a lant from the plot water-logged a month before sowing, on the right specimen of the roots from the control plot is to be seen. In the

water-logged plot, the development of the tap-root is soon arrested and one of the laterals after bending takes its place. In the case illustrated the acting tap-root was followed to some distance and was found to give off very few branches.

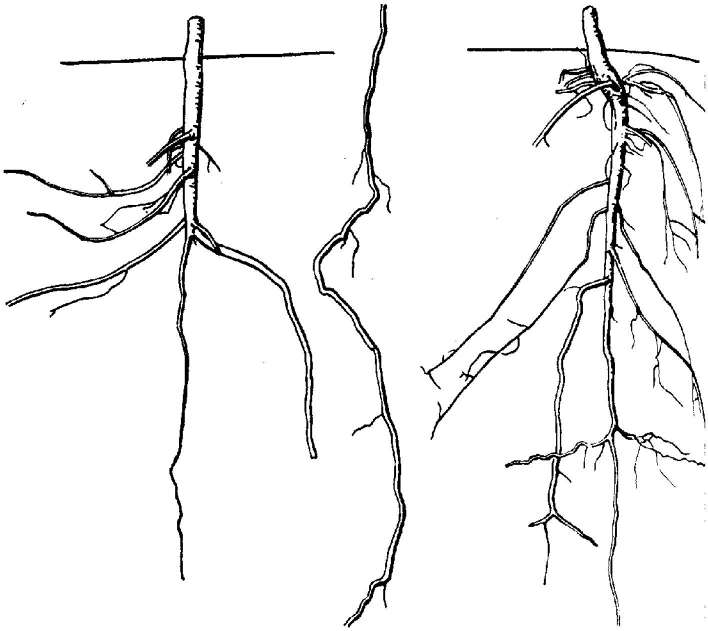
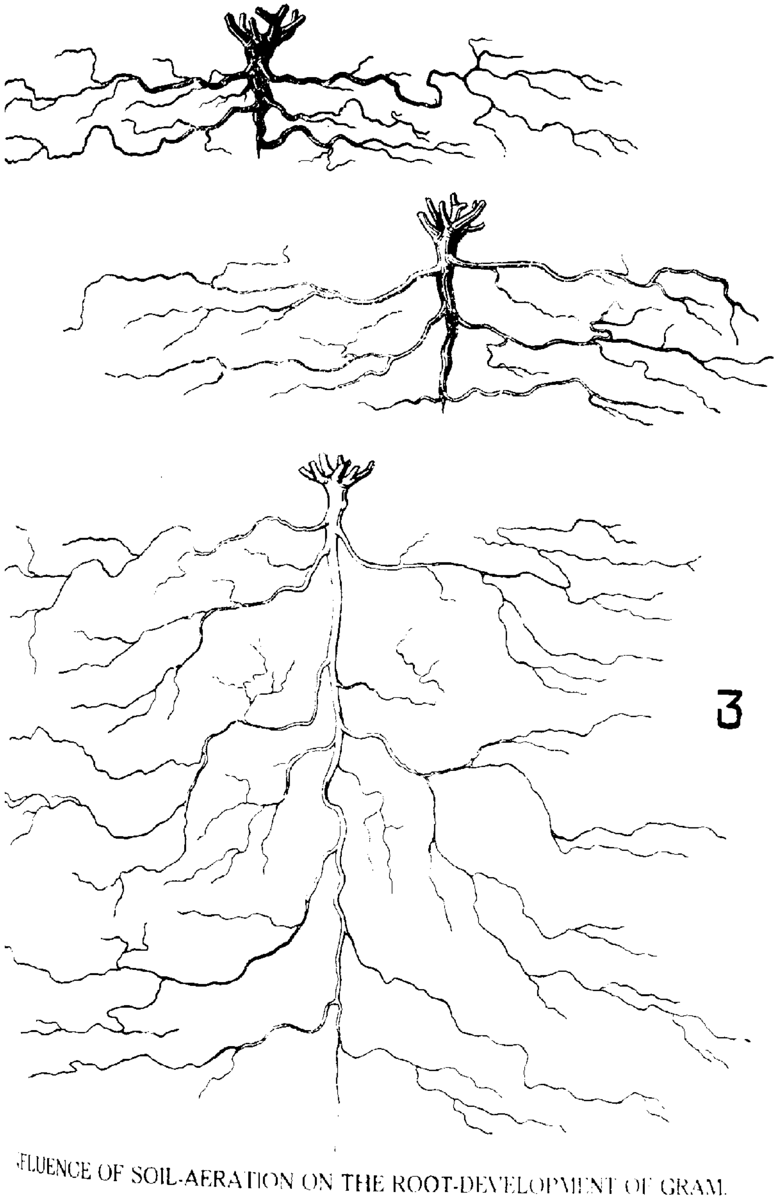


FIG. 2. The root-system of Java indigo showing the effect of water-logging before sowing (left) compared with the control (right).

Similar results have been obtained in the case of gram. In Plate VII are represented the root-systems of three gram plants grown in Pusa soil the same year and within one hundred yards of each other. Fig. 1 represents the root-system on a heavy clay where the aeration of the sub-soil during the previous monsoon was poor. The crop did very well up to flowering time but it set no seed and wilted away. The lower figure shows the root-system of a gram plant in light land. Here the yield of seed was heavy. The middle figure shows the root-system in land intermediate in character. Here the plants did not set seed well and the yield was poor. In the gram crop, root development depends directly on the aeration of the soil and is considerably modified by this factor.

PLATE VII.



FLUENCE OF SOIL-AERATION ON THE ROOT-DEVELOPMENT OF GRAM.

PLATE VI

The loss of fertility through denitrification is not the only isequence of surface water-logging. The physical texture of the l is profoundly affected and when the land dries it is difficult obtain the ideal crumb structure. The clods do not readily ak down under the beam and the soil is gummy to the feel. lloidal substances appear to be formed under these anaerobic ditions which not only hinder the formation of a good tilth but o prevent percolation. It is quite common at Pusa after a very avy monsoon to find the pore-spaces near the surface almost tirely filled with water for some considerable time after the level of rivers and of the ground water has begun to fall. The surface soil es not seem to be able to drain. An improvement in the texture lows if the surface drainage is improved and in cases where organic tter has recently been added to the soil. The gummy substances not then seem to be formed to any great extent and the clods dily break down. These matters urgently require exact and reful investigation and it is difficult to suggest a more promising ld of work for the soil physicist in India.

The extent of the annual loss in the plains of India due to rface water-logging will be apparent if we consider the benefits iich result from improved surface drainage through the adoption the Pusa system.[1] This method consists in dividing up the ea to be drained into units not more than four or five acres in extent parated by trenches. These trenches are about four feet wide d two feet deep with sloping sides and grass borders (Plate VIII). ıe run-off passes over these grass borders and is led away to lowing rice areas while most of the silt is retained on the field. y this device, each field has to deal with its own rainfall only d the run-off is strictly controlled.

The improvement in fertility and in the ease of cultivation hich results from surface drainage are almost past belief. The otanical Area at Pusa has been transformed by this means. The elds have increased, the plots produce even crops and the tilth of e stiffer areas, which was formerly poor, is now vastly improved. veral of the estates in Bihar have adopted this system which the

[1] Soil erosion and surface drainage. *Bulletin No. 53, Agric. Research Institute, Pusa*, 1915.

surrounding cultivators are now copying. As an example of the results obtained, the following report, dated November 16th, 1914, from the Manager of the Dholi estate may be quoted :—

"I have now some 500 bighas at Dholi and my outwork Birowlie, drained by surface drains on the Pusa system.

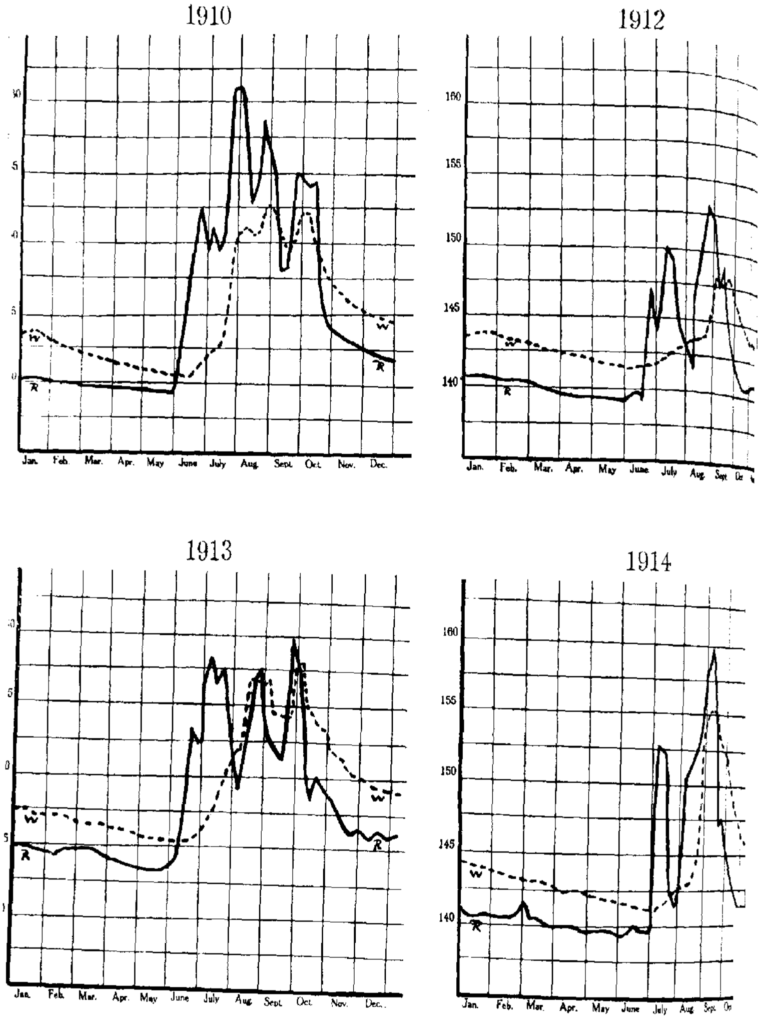
"The improvement of all the lands is very marked, especially at Dholi where most of the lands are on a slope and the high lands suffered from loss of soil from rain-wash and the lower lands used to be water-logged at the time when they should be cultivated for *rabi* and indigo crops.

"The advantage derived from the drainage is most marked in the low-lying lands which were formerly my poorest lands and these last year gave me as good or better returns of wheat and indigo than the high lands; and I am certain will still further improve. These lands I am now able to keep cultivated through the rains and to sow them at the same time as the higher lands."

The most convincing proof however of the advantages of the adoption of this system on the Bihar estates is to be found in the rents paid by the tenants of drained land. On the Dholi estate, several areas, which previously could not be let to tenants at all and which had to be put under cheap crops like oats, fetched high rents when surface drained. In 1914, one of these drained areas under chillies was let for ninety rupees a bigha, another under tobacco for one hundred and fifty rupees a bigha. The improvement in soil-aeration which followed the construction of the surface drains thus rendered possible the substitution of money crops for cheap crops.

THE PREVENTION OF DRAINAGE.

Another aspect of drainage must now be considered. As the rain-inundated region of the Gangetic delta is approached, a well-marked rise in the sub-soil water-level takes place after the monsoon has set in. This is particularly the case in North Bihar where the flow of the rivers is soon checked by the rise of the level of the Ganges. The result is that the rivers overflow and the low-lying areas go under water. The rise in the level of the rivers is followed



CHANGES IN THE RIVER AND WELL LEVELS AT PUSA.

The well levels are shown by dotted lines. The observations are expressed in feet above mean sea level.

y a rise in the water-level of the wells. These movements of the iver-level and of the general ground-water are illustrated in the urves opposite which represent the state of affairs of the river t Pusa and of one of the wells (about a quarter of a mile distant rom the river bank) for the years 1910, 1912, 1913 and 1914. These curves (which were prepared by Mr. Jatindra Nath Sen when fficiating Imperial Agricultural Chemist at Pusa) are typical of he sub-soil water conditions of this tract during the monsoon. It will be seen that the curves of the ground-water level vary according o the year. In some years like 1912 and 1914, the curve is even and no great oscillations of level occur. In others, such as 1910 and 1913, there are well-marked oscillations. These oscillations, from the plant's point of view, are of the greatest importance as a fall in the level of the ground-water means a strong downward pull and the temporary resumption of drainage and of soil-aeration.

These Bihar ground-water and river-level curves have proved to be of particular interest in the study of the wilt disease of Java indigo. It is found that this deep-rooted plant ceases to thrive when the general drainage of the country stops and often dies off altogether due to wilt. It appeared from numerous observations in the field that indigo wilt is caused by water-logging which leads to the destruction of the fine roots and root nodules. This view has been established by direct experiments in lysimeters in which the drainage can be stopped at will. At the beginning of the monsoon of 1918, Java indigo was grown in two sets of lysimeters. In one set, alluvial soil obtained from the Kalianpur farm near Cawnpore was used, in the other set, light Pusa soil was employed. The Kalianpur soil is exceedingly rich in available phosphate (0·318 per cent.) while the Pusa soil, when analysed by Dyer's method, gives very low figures for available phosphate (0·001 per cent.).

The results may be summed up as follows :—

(1) In both Pusa and Kalianpur soil the indigo in the lysimeters with free drainage escaped wilt.

(2) When the drainage openings were closed and water-logging from below took place, all the plants were wilted in both Kalianpur and in Pusa soil.

(3) The wilt in the Kalianpur soil (rich in available phosphate was much worse than in Pusa soil (said to be low in available phosphate).

(4) The growth in Kalianpur soil was much slower than in Pusa soil.

In these lysimeter experiments, the stoppage of drainage brought about an interesting change in the root-system of the indigo and caused the lateral roots to run near the surface. (Fig. 3.

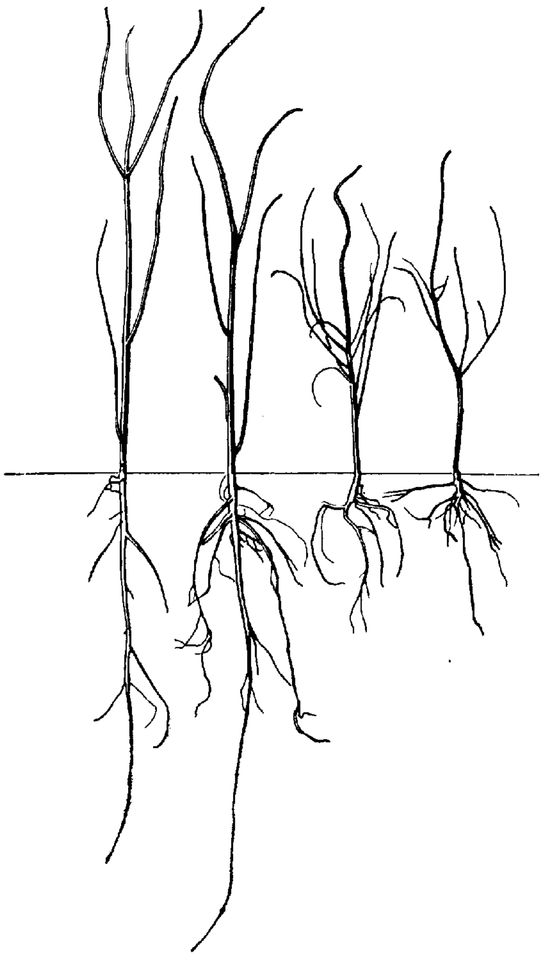


FIG. 3. The effect of water-logging after sowing on the root-development of Java indigo.

On the left are shown two indigo plants from the lysimeter th free drainage. The root development is normal for the variety vn. On the right, two typical plants from the lysimeter in which drainage openings were closed are represented. Here only face roots were developed and the main tap-root was restricted.

SUB-SOIL DRAINAGE.

Another aspect of drainage must now be briefly considered, nely, sub-soil drainage by means of tiles. The openings for this tem in India under present conditions are however much fewer n for surface drainage. The cost per acre of laying tile drains onsiderable and further, if the work is to be of use, it must be well ne. Sub-soil drainage would naturally only be attempted if surface inage is found to be insufficient to improve the aeration of the l. The heavy, black soils of peninsular India afford perhaps best opening for this class of soil improvement. As is well known, se soils expand when wetted and the crops only do well if the ount and distribution of the rainfall is particularly favourable. avy, long-continued rain is almost as harmful as actual famine ditions. Particularly is this the case with cotton which never lds well in wet years. Interesting and valuable results have been tained by Mr. Allan on the heavy black soils at Nagpur where, means of sub-soil drainage, marked improvements have been wn possible.[1] By means of shallow sub-soil drains, Mr. Allan ained the following advantages :—

(a) Surface cultivation is rendered possible even in wet years and the land can be kept clean.

(b) The crops grow faster, are healthier and yield better.

(c) The root development is improved and the resistance to drought is increased.

Mr. Allan's results were obtained on the ordinary heavy black ls at Nagpur. The most productive of this class of land, however, the garden lands irrigated by wells or tanks. These fields are ry valuable, are often well cultivated and large quantities of manure

[1] Allan, R. G. *Bulletin No. 85, Agric. Research Institute, Pusa*, 1918.

and irrigation water are annually applied. They suffer little from erosion as they are constantly under crop, the surface is generally even and the area of each field is small. By means of sub-soil drains discharging into irrigation wells it *might* be possible not only to increase the yield and the number of crops per year but also, by improving the aeration, to diminish the amount of manure and irrigation water required. There seems to be a very promising field of investigation in developing the rich garden lands of the Bombay Presidency and the old poppy fields of the Malwa plateau. Already a great deal of capital has been sunk in these fields. Their owners are often well-to-do men who could easily afford to sink some of their savings in sub-soil drainage if this proves to be a success. The matter is one well worthy of careful investigation.

THE WIDER ASPECTS OF DRAINAGE.

While the cultivator can often do a certain amount to improve the surface drainage of his fields he is quite unable to cope with the larger aspects of the subject. Observations indicate that in many parts of India the surface drainage of large areas is defective and the crops suffer from poor soil-aeration. In some cases, this is due to the existence of extensive shallow, cup-shaped depressions which are unable to discharge the run-off quickly. In others, the general surface drainage is partially held up by roads, embankments and by bridges provided with insufficient water-way. Such problems are clearly beyond the means of the zamindar. They need for their solution the services of the engineer. A detailed drainage map of the area to be improved is obviously the first condition of success. From an inspection of some of these areas in the plains it would appear that a great deal could be done by the provision of a system of drainage canals by which the run-off can be passed either into rivers or led slowly through rice areas at a slightly lower level.

The difficulty in matters such as these is to make a successful beginning. The first step appears to be the study of the general drainage of a few of these partially water-logged tracts of the alluvium, the preparation of a drainage map combined with a study

the rivers where this is necessary. The drawing up of definite rking-plans would follow and progressive landowners would obably be found who would be willing to execute a small project der direction. These proposals do not involve a great deal of pense. A certain number of engineers with the necessary agri-ltural insight in all probability exist in the country now and, set to work on this question, would rapidly justify themselves. eir assistance in this matter is essential. The cultivators and nindars are so intent on their own small areas of land that they nnot be expected to evolve a scientific scheme of drainage for the untry-side. Clearly it is for the State to provide a directing hand. this direction a step forward has already been made by one dian province. In the *Punjab Government Gazette* of September th, 1918, the constitution and duties of a Drainage Board for the ovince were announced. In the Government Resolution on is matter it is stated that "water-logging is due to many other uses than seepage or over-irrigation from canals, for instance nperfect natural drainage or the obstruction of natural drainage r roads, railways, irrigation channels and zamindars' embankments. he evil is of steady growth in parts of the province and in some aces threatens not only the prosperity but the health of the rural pulation and involves also serious loss to Government revenue. itherto it has been dealt with only spasmodically. There has been o settled policy either for investigation or for action. The question hould, therefore, now be taken up for the province as a whole."

NOTES ON THE "RING DISEASE" OF POTATO.

BY

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AND

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In the potato tracts of the Bombay Presidency the greatest enemy to the successful growth of this crop is the presence of the "ring disease." Other pests and diseases exist, but they can more or less be kept in check, but in the case of the ring disease, the cultivators have been helpless, largely because they have not been able to determine the source of the disease, and the means by which it is transferred from crop to crop. In the past, the regular and frequent importation of fresh seed from Italy has been the method adopted to keep the disease in hand, but it was never determined whether the success of this method was due to greater resisting power in the imported seed, or whether its gradual deterioration was due to continually increasing infection after importation. During the years since 1915 the import of such seed has been impossible, and the question of keeping the disease in check while using local seed became a matter of urgent necessity to the potato industry.

The ring disease of potato, it may be noted, is a bacterial wilt and though its ravages had proved a very serious matter in Bombay as long ago as 1891, it was only accurately investigated and its nature determined by Coleman in 1909. Its attack produces a sudden wilting of the plant, when such tubers as are attached to

e plant will be found to show a brown ring in the vascular tissue, mmencing as a rule near the point of attachment of the tuber to e plant, but spreading round the whole tuber. The infection lo affects the lower part of the stem in which the ring can usually lo be distinctly seen.

The damage done by the disease is very great. Often twenty thirty per cent. of the plants in a plot die, and we have known as ich as seventy or eighty per cent. of what seemed at one time a ry promising crop to be lost on account of the disease. It is nost universally found in the potato-growing tracts of the Deccan.

The most important point in combating this disease is to find usual means of infection. It has been known, since the investitions of Coleman (1909), that diseased seed tubers would produce eased plants, and, moreover, that infection could also take place ough infected soil. But the relative importance of these methods actual practice has not been determined and it was absolutely essary to our work to find out how the disease was most frently carried from crop to crop. In other words, if soil infection s the *chief* source of the disease in our fields, it would be necessary fight the disease by keeping infected fields free from susceptible nts until the bacteria which cause the disease die out. If, on other hand, the seed was the chief means of infection, careful ention to the seed would be the primary, and might even be the ly necessary, method of precaution.

The determination of these points was the object of a series of experiments in 1917 and 1918, in which potatoes were grown in sh river soil in which no infection could have occurred, and ection was introduced in the following ways :—

(1) by planting potatoes containing ring disease;
(2) by mixing pieces of potato attacked by ring disease with the *soil*;
(3) by watering the *soil* with water in which cut sets of potatoes attacked by ring disease had been allowed to lie for half an hour;
(4) by inserting pieces of potato infected with ring disease in the potato *sets*;

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(5) by soaking the potato *sets* in water used to wash potatoes affected with ring disease ;

(6) by using, *as seed*, tubers from a plant affected with the disease, but which themselves showed no sign of the disease ;

(7) by using a knife infected by cutting affected sets, to cut sound potatoes for planting ;

Duplicate pots were taken in each case, but the results were consistent throughout, and gave results as follows :—

(1) Where diseased potatoes (eight sets) were planted.

(*a*) Six sets did not germinate ;

(*b*) one set germinated, but began to wither eleven days later, and was completely dead after a week ;

(*c*) one set germinated and grew fairly well. It however produced no tubers, and after ripening the original set was found to be rotten.

(2) Where the *soil* was infected with fragments of infected potato. Six sets were planted, and all germinated. Seven days later one was wilting. After eleven days two plants were dead and two were wilting. A week later one more was dead, but the other affected plant was making an effort to throw out new buds. It was in vain however, and seven days after it was dead. At this time (4½ weeks after planting) all were affected and either dead or dying save one plant. This latter remained apparently healthy and matured normally giving three ripe tubers. On cutting these, however, all were found showing signs of ring disease in the tuber.

Infection of the soil by fragments of diseased tubers is, therefore, very fatal, and even if the plants do not die, the tubers are very likely to be diseased.

(3) Where the *soil* was infected by the water in which diseased potatoes had been soaked.

Five sets out of six germinated, but all died of ring disease. They were quite healthy, however, for over

three weeks, and then wilted and died in rapid succession. After six weeks all were dead.

This experiment shows the extremely infective character of water in which diseased sets have been soaked.

(4) Where the *sets* were infected by the insertion of fragments of diseased tubers.

The results of this method of infection showed it to be by no means so certain or so rapid as those previously considered. Out of six plants, one died in six weeks, and two more a week later. The remainder (3) ripened and were harvested in due course three months after. Of the tubers produced, those from one plant all showed signs of ring disease, from a second all showed signs except one and in this none could be detected, while in the third no ring disease could be observed in any of the tubers produced.

(5) Where the *sets* were infected by soaking in the water in which diseased potatoes had been placed.

In this case all the potatoes germinated normally. The first sign of disease was observed twenty-four days later, but the progress was very rapid and all were dead thirty-six days after planting.

(6) Where the *sets* were from infected plants, but themselves showed no signs of ring disease.

Out of eight such sets planted two died of ring disease five weeks after planting. The remainder were harvested but *all the tubers produced showed signs of ring disease.*

This experiment showed clearly that the potatoes which were ...ained from ring-disease-affected plants but showed themselves ...sign of the disease were unsafe as seed.

(7) Where the sets, though healthy, were cut with a knife previously used to cut a potato affected with ring disease.

Fifteen healthy potato sets were planted, their only connection with the disease being that the knife used

for cutting them had previously been used to c diseased potatoes. Fourteen sets germinated i due course and in good time. A month later fi of them were dead, and gradually all died befo maturity except two. These two matured, b all the tubers on them were half rotted with rin disease when they were taken out.

This experiment shows the extreme infectiveness of the diseas

The position is, therefore, clear. The ring disease is extremel infectious and may be carried by diseased sets or by anything whic has been in contact with them. The soil may carry the disea whether it has been infected by diseased tubers, by water in whic diseased tubers have been washed, or by remnants of diseased potat plants remaining in the soil. And even the knives used for cuttin a few diseased tubers may infect a large part of a crop, when th seed is otherwise of good quality. This last fact is beginning no to be realized by the cultivators, and we are introducing a system o sterilizing the knife used for cutting sets with hot water after contac with diseased potatoes, among the more advanced cultivator of the Poona potato tract.

Perhaps the chief interest, however, lies in the infection throug the soil, and the length of time during which the bacteria ar capable of living there, and infecting the following crop. It i obvious that if the organism is capable of making soil infective fo a long period potato cultivation is doomed in these districts. We have hence made experiments to ascertain how soon potatoes ca again be safely grown after the soil is thoroughly infected with th disease.

Pots were taken in which all the plants had died through so infection with water in which diseased sets had been soaked, bu from which all remnants of diseased plants were removed. The new healthy sets were planted (1) immediately, (2) after two to thre months, and (3) after about six months. In the meantime the so was allowed to stand without cultivation.

Where healthy potato sets were planted immediately after th removal of the previous (diseased) crop, all the plants were affected

t of four plants one died within three weeks of planting, another thin four weeks, while a month later a third was dead. The fourth s attacked, but was able to throw out new side shoots and came to turity. No tubers were however formed. In this case, there-e, all plants were affected.

The soil from which the last crop was harvested was then wed to stand for two and a half months (November 1st to January h) and then re-planted. Four plants were obtained. Three nained healthy throughout, produced good tubers which showed sign of ring disease. The fourth plant began to droop after ee months, and was then dug up. Of the three potatoes produced this plant, two were apparently healthy, but the third was loubtedly attacked with ring disease.

The same pot was again sown a week later (eleven months after original infection), the plants matured healthily and the tubers wed no sign of ring disease.

In a further experiment, the soil was thoroughly infected with ased material and healthy sets planted immediately. All died lue course, and then, after removal of the plant residues, the soil s allowed to stand for five months without a crop (August 18th to nary 18th). It was then planted with healthy sets. Under se circumstances all the sets germinated perfectly, grew healthily l ripened normally. No tuber or plant showed any sign of ring ease.

As this matter appeared very important the experiment was eated with no less than nine pots in all of which the soil was roughly infected as shown by the complete loss of the previous p. In each case, after removal of the plants, the soil was allowed stand for $6\frac{1}{2}$ months (September 11th to March 27th) and then nted with healthy sets. All germinated, and no sign of ring ease was found throughout growth. None of the tubers pro-ced were infected with ring disease.

In summary, we may say that the experiments recorded confirm vious results as to the conveyance of the ring disease of potatoes m crop to crop both through the seed and the soil. They show the tremely infectious character of the disease in that not only the

seed but also everything which has been in contact with it, even t knife by which diseased sets have been cut, are capable of conveyi the disease to a healthy tuber and hence to a healthy plant.

The infection does not, however, live long in the soil in a vir lent enough condition to affect new plants. After two and a ha months the infectiveness was reduced by at least seventy-five p cent. After five to six and a half months the infectiveness of t soil has disappeared.* It would appear clear, therefore, that if la is kept free from potato plants, or other plants, like tobacco, capab of carrying the disease, for six months, the danger of infecti through the soil is very small, if, indeed, it is not entirely eliminate Inasmuch as the potato crop, usually reaped in February or Marc is never planted on the same land until October or Novembe and the crop reaped in September or October is never planted on th same land until the following June, it would appear that the dange of infection through the soil under Deccan conditions is small, if th diseased plants are carefully removed in each crop. This agree with practical experience and enables attention to be focussed o the provision of disease-free seed as the main line of the attack o this very fatal disease.

* As against this, Butler reports that five years are considered as necessary in Ame to remove the infectiveness of the bacterial wilt of tobacco caused by the same organis

RATE OF NITRIFICATION OF DIFFERENT GREEN MANURES AND PARTS OF GREEN MANURES AND THE INFLUENCE OF CROP RESIDUES ON NITRIFICATION.

BY

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GREEN-MANURING is a subject of world-wide interest, as the practice is in vogue in all countries and has proved effective in maintaining or increasing the fertility of the soil. In support of this practice of ploughing in a green crop into the soil various reasons are usually given. However, analyses of soil, before and after green-manuring, have shown that the organic matter and the nitrogen added to the soil by the green crop are of all others the two most important factors on which the value of green-manuring chiefly depends: and field trials on a large scale have further made it evident that the practice is an economical one, that is, it can at a comparatively smaller cost per unit provide the organic matter and the nitrogen necessary to improve the soil.

In green-manuring the changes brought about by the addition of large amounts of organic matter are no doubt an important asset as affecting the general permanent fertility of the soil by increasing its humus content and improving its physical property, but what is of immediate benefit to the crop succeeding the green manure is the addition of nitrogenous material which becomes readily available by being changed into nitrates in which form the nitrogen is mainly taken up by plants. In order to convert the organic matter into humus and the nitrogenous material into nitrates it is necessary

that green manure should first be thoroughly decomposed. The conditions necessary for the decomposition of a particular green crop cannot be found everywhere as there are many variations in conditions of soil and climate in different countries. Hence different kinds of green manure have been tried under varying conditions of soil and climate all over the world. These empirical trials have yielded plants for green-manuring purposes suitable to each particular area, but in spite of the fact that the course suggested by empirical trials is followed in practice and is usually attended with success, still many times failures also occur. There are numerous such instances on record of the failure of the treatment of the soil with green manures to promote greater fertility. It is difficult at first sight to account for the absence of the specific effect of the addition of organic nitrogen on crop yield. This is no doubt due to the paucity of research from the biological side of the question. However, besides the work done in other countries some valuable results of work done by the Agricultural Departments in India are already published. The work on the gases of swamp rice soils by Harrison and Aiyer[1] deals with the practice of green-manuring for rice and hence does not relate to conditions obtaining in the use of green manures for the succeeding *rabi* (winter) crops. This latter aspect of the question is dealt with by Hutchinson and Milligan[2] who have studied the decomposition of green manures from a bacteriological point of view in the laboratory, besides carrying out a number of experiments in the field. These authors used sann-hemp as green manure and carried out their experiments in Pusa soil under varying conditions of moisture and depth of burying the green manure in the soil. As the result of their work they have made it clear that the value of green manure depends on the presence of proper conditions of moisture in order to effect its complete decomposition and that rainfall and transpiration of water from the green manure crop itself affect the moisture left in the soil for the successful decomposition of the green manure. Another point of importance to which

[1] Harrison and Aiyer. "The gases of swamp rice soils." *Memoirs, Dept. of Agric., India Chemical Series*, vol. III, no. 3.

[2] Hutchinson and Milligan. *Agric. Research Inst., Pusa, Bulletin No.* [illegible]

ention is drawn by the authors relates to the concentration of rogen. The authors point out that in case of nitrogenous manures ertain concentration of nitrogen in the available condition is essary to show the beneficial manurial effect. These observans account for many failures of green manures and also indicate optimum conditions necessary for successful decomposition of een manures.

It is proposed in this paper to present the results of an attempt study, on similar lines, as to what happens to green manure en incorporated in the soil for the succeeding *rabi* crop. In ler to exclude the possibility of failure to decompose we restricted rselves under previously determined optimum conditions of moise, temperature and nitrogen concentration mentioned by Hutchin1 and Milligan[1] as necessary for successful decomposition of sannmp. We have however extended our work to the study of decomsition of different kinds of green manures in order to find out ether there is anything in the nature of the constituents of different een manures, which makes one kind of green manure more suitable an another. We have also included in our work the study of the composition of different parts of green manure--leaves, stems and ots -incorporated separately in the soil, in order to ascertain ether the different ratio of nitrogenous to non-nitrogenous constients existing in the different parts affects the course of nitrogen anges. We have also attempted to find out what happens to the ndecomposed tissues or crop residues and to see the effect of the me on the process of nitrification.

Before proceeding we may just mention that in our opinion e value of green manure depends on the fact, whether after its ecomposition it is able to provide a certain amount of available itrogenous food and not so much on the quantity of organic material hich it is likely to add to the soil. The soils to which green manures re added do already contain a much greater amount of organic itrogen than the quantity added in the form of green manures. hus Pusa soil representing the type of soils in the Gangetic alluvial

[1] *Loc. cit.*

plain is found to contain 70 to 90 milligrams N per 100 grams soil or 1,750 to 2,000 lb. per 9-inch acre, while the nitrogen added as green manure to the soil is from 1·5 to 2·0 milligrams per 100 grams of soil or 37 to 50 lb. per acre. But the large difference it makes to the immediately succeeding crops is due not to the actual amount added but what happens to it after it is incorporated in the soil. If we examine the original soil and the same soil to which green manure has been added after some weeks we find slight differences in the amount of total nitrogen, but of this only a small percentage is found as nitrates in the original soil, while under optimum conditions nearly 60 per cent. (under field conditions slightly less) of the added nitrogen is generally found nitrified. We say "generally" because it will be shown later that this may not be correct for all green manures. That there is a direct relation between the nitrates present in the soil and the growth of the crop is observed by all investigators, but it is worth noticing the singular coincidence between the interval necessary for maximum accumulation of nitrates after incorporation of green-manuring material as found in the laboratory and the optimum interval that should be allowed to pass after burial of the green manure before the sowing of the succeeding crop. The period for maximum accumulation of nitrates was found to be eight weeks at Pusa by Hutchinson in case of sann-hemp (*Crotalaria juncea*) as green manure in Pusa soil and the optimum interval for transplanting tobacco after sann-hemp buried as green manure was also found to be eight weeks by Howard. Another case of nitrate accumulation and the benefits to succeeding crops is noticed by J. Sen in a recent number of the *Journal of Agricultural Science* (Vol. IX, No. 1), wherein the author says : "It is also interesting to note here another point which shows a close relation between the growth of plants and the nitrification processes going on in the soil. The period during which nitrates began to accumulate in the soils investigated coincides with one of the periods of rapid plant growth in Bihar." We may take it for granted therefore that nitrate formation or rather nitrate accumulation largely influences the growth of succeeding crops, and hence attention was first given to the study of the nitrate formation in preference to all the multip

processes that take place in the soil after the incorporation of any organic material and which we shall have occasion to discuss later on. The results obtained so far are detailed in this paper as being of interest to other workers in the field, and also with a view to invite criticism so as to enable us to direct our efforts in the proper direction in the light of these criticisms.

Six leguminous plants were chosen for the purpose of the experiment. The plants selected ranged from those possessing very thin and slender stems to those having thick woody ones. The average size of their branches is represented in the accompanying

1. Sann-hemp. 2. Dhaincha. 3. Tamarind. 4. Guvar. 5. Cow-pea. 6. Gokarn.

photograph so as to give an approximate idea of their respective size at the time of burying them in the soil. Of these the first three are of the woody and the last three of the succulent type. Their common and botanical names are as under :—

Sann-hemp (*Crotalaria juncea*).
Dhaincha (*Sesbania aculeata*).
Tamarind (*Tamarindus indica*).
Guvar (*Cyamopsis psoralioides*).

Cow-pea (*Vigna catjang*).

Gokarn (*Clitoria ternatea*).

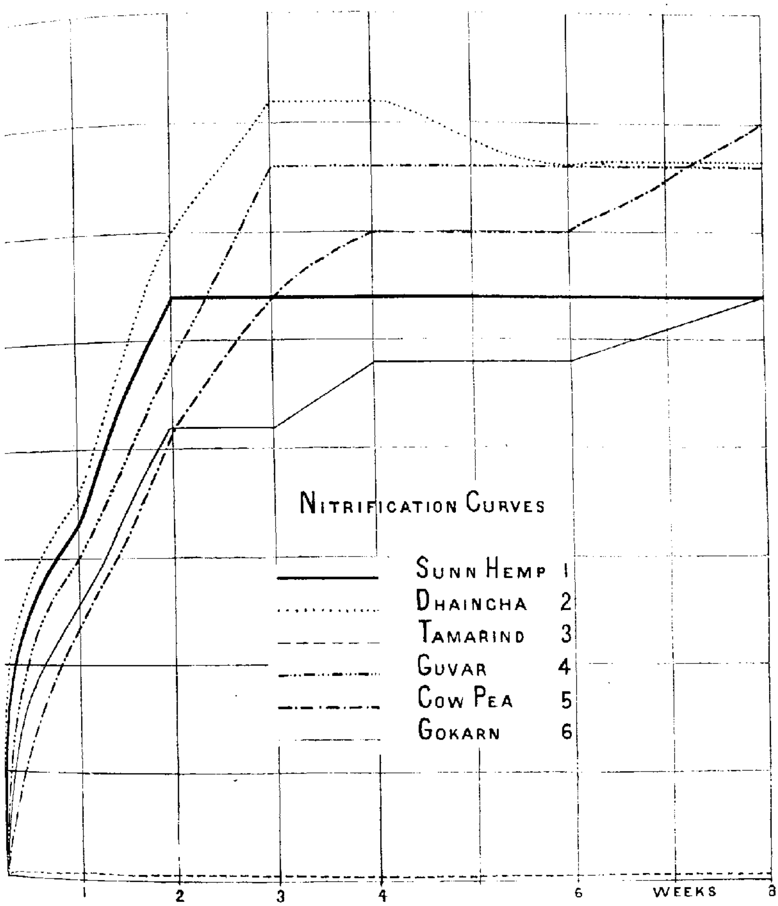
Of these, sann-hemp, *dhaincha*, *guvar* and cow-pea are commonly used as green manures. Tamarind was included with a view to see the effect of a greater proportion of woody tissue to the leaves, and *gokarn* for the opposite reason having the slenderest stem of all with a comparatively higher amount of foliage.

Seeds of these were sown separately in a small plot so as to allow their growth in the same soil as was to be used later on for nitrification experiments and under the same conditions. This process, it was thought, would avoid all the other factors likely to be urged to discount the results obtained if the crops were got from the different fields.

The plants were allowed to grow for six weeks when they were uprooted and the percentage of nitrogen was determined in each case after proper sampling. Whole plants were taken root and all. Green plants were cut to pieces, averaging about half an inch and these were separately added to each kilo of air-dry Pusa soil at the rate of 30 milligrams of organic nitrogen in the form of green manure per 100 grams of dry soil. Water was added to the soil so as to make up the moisture content of the soil up to 16 per cent. allowance being made for the water already contained in the green plants. The soil and the plant were thoroughly mixed with the hand and each lot filled in separate glass jars. The jars were covered and kept at 30°C. in the incubator. The quantities of nitrogen and moisture stated above were taken as they had been found to be the optimum for the Pusa soil. Samples for analysis were taken after thoroughly mixing the soil, to determine the amount of ammonia, nitrite and nitrate formed at the end of each week for the first four weeks, after which time determinations were made after an interval of two weeks. Nitrates were determined by the phenol-sulphonic acid method, nitrites by Greiss-Ilosvay method, and ammonia was determined by distilling with magnesia the acidified soil extract.

Chart I illustrates the rate of nitrate formation or more correctly speaking nitrate accumulation in the soil after addition of the green manure.

CHART I.



Nitrification Curves
Sunn Hemp 1
Dhaincha 2
Tamarind 3
Guvar 4
Cow Pea 5
Gokarn 6
1
2
3
4
6
WEEKS
8

The result with tamarind plants is a negative one. Want nitrification cannot in this case be attributed to insufficient isture or low temperature as the experiment was carried out ler optimum conditions of moisture and temperature and rate of plication of nitrogenous material. It is striking as it is generally umed that all legumes enrich the soil by supplying organic rogen and that all organic nitrogen in any form added to the soil itrified to a certain extent. There is no change in the reaction the soil which remained basic. It may as well be mentioned it under the optimum conditions of moisture and temperature. omposition of the tamarind plant tissue and also ammonifican to a certain extent had taken place. The failure to nitrify refore is not due to want of decomposition but may be regarded due to some substance present in the plant which actually ibits the action of nitrifiers. Experiments are in progress to l this out and we must await the results of further inquiry ore we can definitely ascribe this result to any particular ise.

The rate of nitrification of the succulent plants in this experint is in inverse ratio to the succulence of the stems; the more ider and hence more easily decomposable the tissue, the slower nitrification: which is rather contrary to general expectation. is assumed on *a priori* grounds that the more succulent a plant is, e more easily it is decomposed, and hence more easily available nitrogen contained in it should become. That it is easily composed is correct, but on account of the very fact of its easy composition the nitrate accumulation power is lowered in the ginning. To venture an explanation of the fact certain possibilis present themselves which may be put down here briefly. Of ese the first two explain why nitrate formation may be retarded, d are based on the assumption that nitrates accumulated in soils present the total quantity of nitrates formed.

1. Most of the species of putrefactive bacteria that develop the addition of green manure to a soil can attack both carbonaous material as well as nitrogenous, and, as a result of some prelinary experiments on the subject, we found that when pure

cultures of some of these putrefactive bacteria were separately inoculated into peptone solutions with and without glucose a comparatively smaller amount of ammonia was obtained by distillation with magnesia from peptone with glucose than from peptone alone. Similar results were obtained with the complex soil flora acting on oilcake with and without glucose. We, therefore, assume that the course of nitrification will be similarly affected by easily decomposable carbonaceous material which is found in greater proportion, in the form of parenchymatous tissue, in the succulent plants than in the woody ones. It is in our opinion on account of the presence of this greater amount of easily oxidisable carbonaceous material in the succulent tissue that we get a smaller amount of nitrogenous material changed into ammoniacal condition and consequently less nitrification in the succulent plants than in the woody ones in the early stages of decomposition. It must be admitted that this explanation is a tentative one. It may have to be abandoned if further experiments do not confirm the results already obtained.

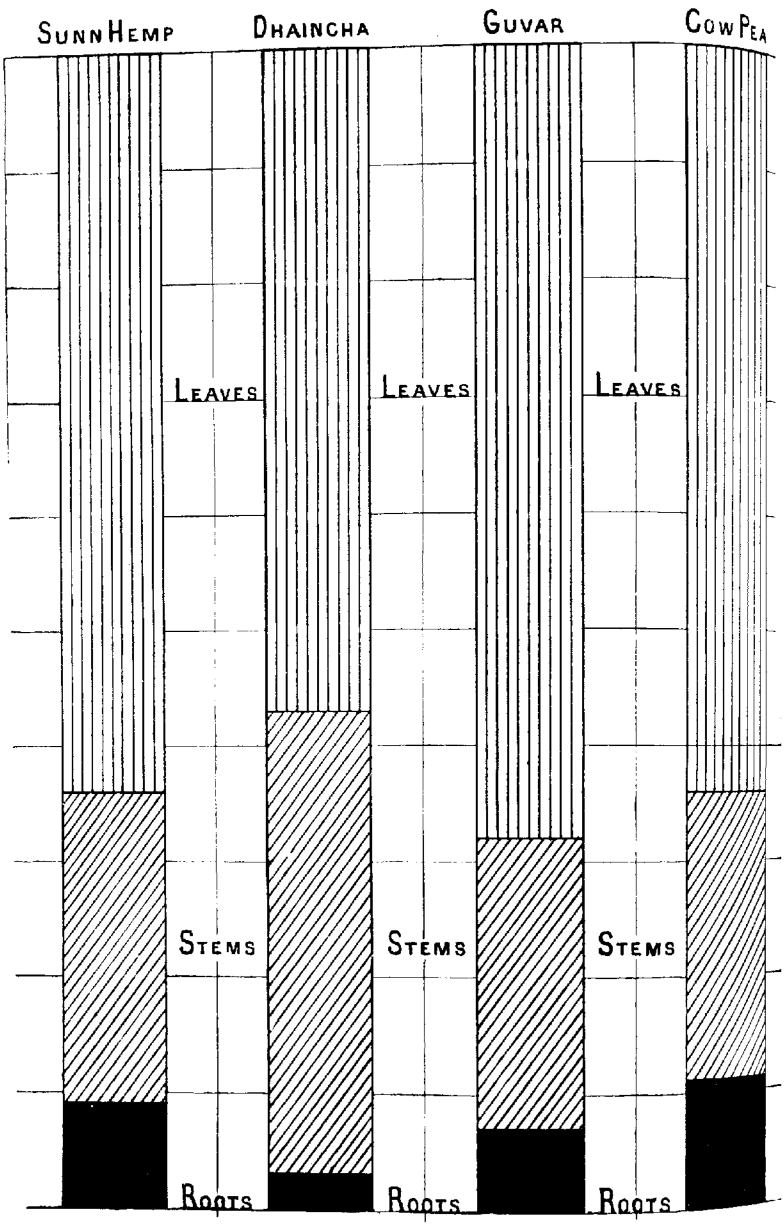
2. The second possibility is that the putrefactive bacteria attacking these succulent tissues multiply to such an extent in the beginning that by their rapid growth they form bacterio-toxins and other products such as indol and skatol, as well as other deleterious substances found by Schreiner, Shorey and others. Though formed in minute quantities under aerobic conditions their presence may retard nitrification.

The next two possibilities presuppose that nitrate accumulation is a resultant of all kinds of bacterial activities going on in the soil and that nitrate accumulation is not an absolute measure of nitrate formation but the algebraic sum of nitrate formation and nitrate reduction.

3. The lower amount of nitrates formed in the case of succulent plants is due to the fact that destruction of nitrates takes place. The greater number of bacteria that develop on addition of green manures destroy the nitrates that are actually formed, in other words true denitrification sets in simultaneously with nitrate formation.

4. The further alternative is that some of the putrefactive bacteria assimilate the nitrates formed for their own growth and

NITROGEN CONTENT



vert it into bacterial proteins which become available later on. thout attempting to solve at this stage which or how many of se possibilities are correct we shall take up another question in empting to answer which we shall have occasion to turn to the cussion of these alternative hypotheses.

A question is often raised, to what part of the plant the benefit green manure is due, the portion above ground or the portion ow ground, *i.e.*, the root residues, and it is suggested that the der-ground portion, *i.e.*, the root residues, is an important et, and it is further pointed out that if this is so, it is no use burying whole of the crop of the green manure, but the green manure l be more economically used if the portion above ground is utilized the farmer or his cattle as feeding stuff and the portion below und left in the soil to rot. It has been assumed by some writers t the nodule bacteria being associated with the roots and fixing atmospheric nitrogen there, the roots are likely to contain st of the nitrogen contained in the leguminous plant, this ief being strengthened by the fact that a crop of cereals after a vious leguminous one is always better than that after a previous real crop. The only point of difference in the two cases lies in e *roots and stubble* left in the ground, those in the case of uminous plant containing more nitrogen.

However that may be, the question cannot be answered by alogy because we have not to compare the effect of root residues a leguminous crop with those of a cereal one. What we have compare is the effect of the above-ground portion with the under-ound portion of the leguminous plant used as green manure. here can be no doubt as to which of these contains the greater nount of nitrogen. From the various figures of analysis published, can be seen at a glance that the portion above ground contains arly three-fourths of the nitrogen contained in the whole plant. here may be exceptions, but for our purpose in this case the four lants under experiment which are commonly used as green anures, *viz.*, sann-hemp, *dhaincha*, *guvar* and cow-pea, this is so. hart II shows the nitrogen content of leaves, stems and roots from ur analyses made for the purpose of experiments described later on.

The only way in which it seems possible that this might wrong is by having recourse to a supposition that all the nodules which are found on the roots of the *Leguminosæ* do not represent the full number borne by the plant, but a considerably larger number are formed on the roots and get loose from the plants ; these subsequently rot in the soil and thus add a considerable amount of nitrogen to the soil. Leaving this more or less far fetched assumption aside, let us consider only the amounts actually found by analysis which show distribution of nitrogen in the proportion stated above. As is already pointed out, however, in the case of soil nitrogen, it is not sufficient merely to consider the quantity of organic nitrogen, but we must also know its ready availability which may differ so much as to make the root residues more valuable than the portion above ground. In order to test this, leaves, stems and roots with nodules in the case of four of the plants were carefully analysed, and portions containing equal amounts of nitrogen at the rate of 30 milligrams nitrogen per 100 grams of soil were added and allowed to nitrify as before and the weekly determinations of ammonia, nitrite and nitrate made. The following two selected charts (Nos. III and IV) illustrate what happens. All the charts represent the same phenomenon and hence those of *dhaincha* and sann-hemp are shown as typical. Another chart (No. V) comparing the nitrifiability of four kinds of leaves is also given which shows differences in the rate of nitrification. There is hardly any choice as regards the nitrifiability of roots and stems of any of these, the amount being so small, but where nodules preponderate as in the case of *dhaincha* there is a slight tendency to larger amounts of nitrates accumulating.

The results so far obtained clearly show that during the first two months of the burial of the green manure, up to which period only results of experiments are available at the time of writing, it is the leaves that are nitrified in the soil, the stems and roots, if anything, inhibiting the nitrate formation or destroying the nitrates formed from leaves, and hence the accumulation of nitrates in the first two months after green-manuring is due to leaves of the plant and not to stems and roots, and, in our opinion, the beneficial effect

CHART III.

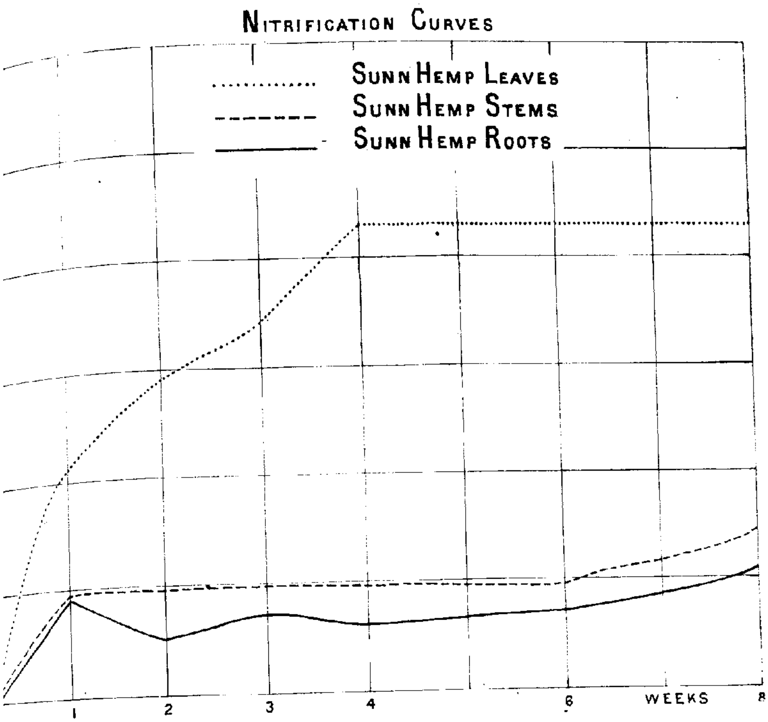


CHART IV.

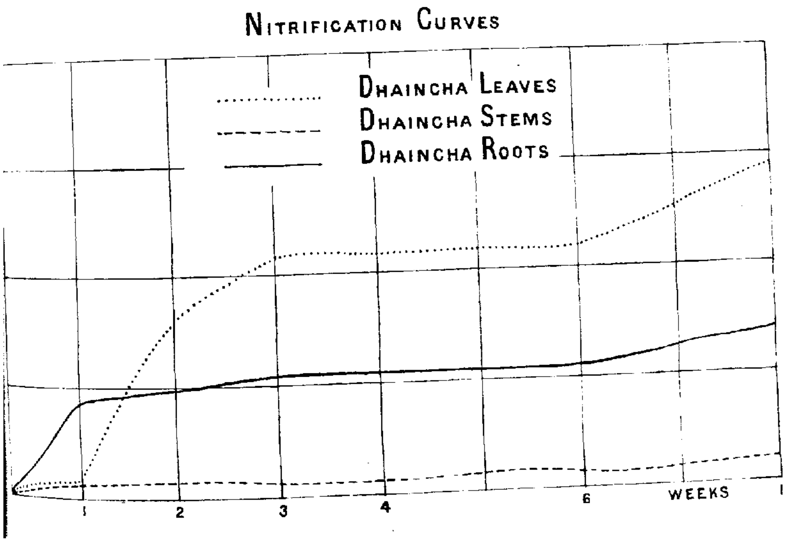
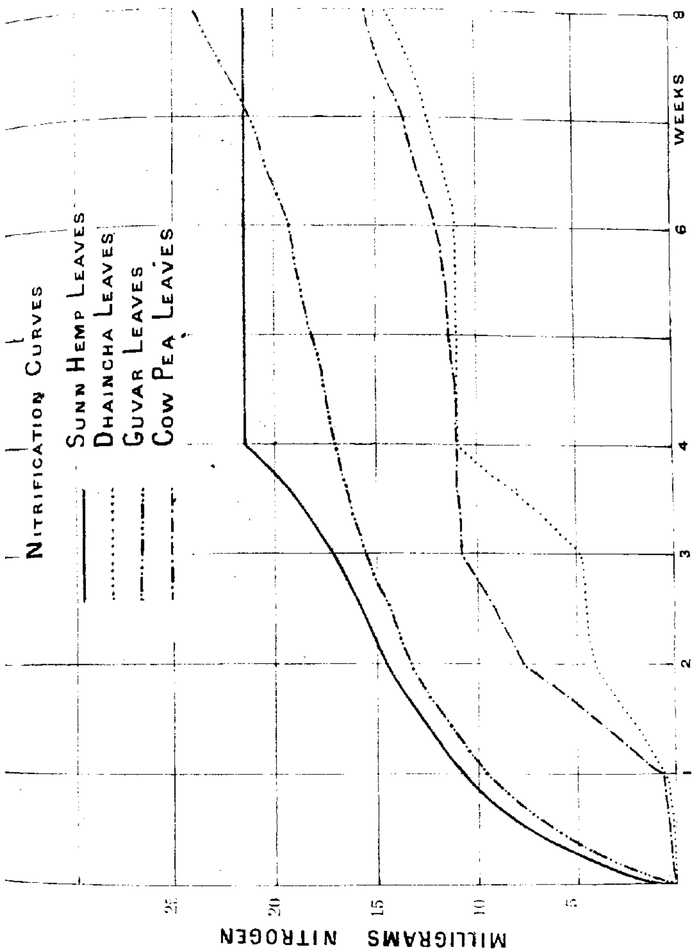


CHART V.



NITRIFICATION CURVES
SUNN HEMP LEAVES
DHAINCHA LEAVES
GUVAR LEAVES
COW PEA LEAVES
MILLIGRAMS NITROGEN
WEEKS
5
10
15
20
25
1
2
3
4
6
8

green-manuring on the succeeding crop is to be chiefly attributed the nitrates derived principally from the nitrogenous material the leaves of the green manure crop. The quicker rate of nitrifi-tion of the nitrogen in leaves and the non-nitrifiability observed the case of the nitrogenous material in roots and stems rther suggests that the beneficial effect which is observed in e cereal crop after a leguminous one as compared with the real after a cereal, is also due principally to the nitrogen rived from leaves which are seen fallen on the land carrying a guminous crop; only a small part of it can be attributed to root sidues.

Besides the benefit derived from the accumulated nitrates the crop directly following the green manure, sometimes a sidual beneficial effect of the green manure is observed on a cond crop following in close succession to the first one after een-manuring. This beneficial effect derived by the second crop nnot be reasonably ascribed to nitrates previously accumulated, ce the nitrates so accumulated are already used up by the first crop rectly following the green manure, and there is nothing left of the een manure in the soil except the undecomposed portion of stems nd roots. We have now to account for the residual effect, which is any times observed, as well as that part of the effect of residues the form of roots of the leguminous crops (apart from that due the fall of leaves) which is found to benefit the succeeding cereal op, and we have also to see why the roots and stems are not vourable to nitrate accumulation. These effects may be accounted r in various ways. In order to examine the questions comprehen-vely, let us see what is likely to happen to the organic material hen incorporated in the soil. The process is likely to give rise to a umber of changes, any one of which may dominate the rest, depend-g on the air, water-supply, temperature and the reaction of the il itself and, as we have seen, ammonification and subsequently trification predominates in the first instance at least for eight weeks hen the major portion of the nitrates are formed and subsequently moved by the succeeding crops. There are still left in the soil a sidual nitrogenous material not nitrified as yet, and such other

structures as cellulose and woody tissues which resist for a long time the action of the soil flora. The possibilities of further action are :

(1) The residual nitrogen, *i.e.*, the un-nitrified nitrogen is likely to be slowly nitrified until finally all the nitrogen is accounted for in other words a steady but slow continuation of the nitrification process.

(2) The soil being depleted of its large quantities of nitrates nitrogen-fixing bacteria, *e.g.*, *Azotobacter Chroococcum* and *Clostridium Pastorianus* and others, are likely to come in action using the cellulose and other soluble carbohydrates that may still be left. The nitrogen accumulated in this way is likely to be nitrified again and prove beneficial to the succeeding crop. Thus the plant residue are likely to prove an indirect source of nitrogen.

(3) If the nitrates formed by the above two processes remain unutilized by a long interval elapsing between the subsequent introduction of another crop they are likely to be assimilated by certain organisms by converting them into bacterial proteins, the necessary conditions being easily decomposable organic matter *e.g.*, carbohydrates and air.

(4) If by chance the air supply be cut off by water-logging or some such accident the nitrates are likely to be decomposed into either of the following : nitrites, or any of the gases, ammonia nitrogen, nitrous or nitric oxide.

Of these processes the last is the most harmful and depend upon the cutting of air supply which we need not assume for normal well drained arable soil. Nitrate assimilation is not so harmful as the disappearance of nitrates in this case is only temporary the bacterial proteins formed by bacteria are likely to be nitrified again. Of the first two suppositions the second has been studied at Rothamsted and the results published in a paper "Effect of Plant Residues on Nitrogen Fixation" contributed by Hutchinson in a recent number of the *Journal of Agricultural Science* (Vol. IX No. 1).

A short summary of the conclusions arrived at by the author may be useful in this connection and is therefore given :

· The nitrogen content of sand or soil may be appreciably creased by the activity of Azotobacter when some suitable source energy is supplied. Sugar and starch are suitable for this purpose t distinct gains of nitrogen have also been obtained by the use of ant residues. Distinct gains of crop resulted from the application carbonaceous compounds under favourable soil conditions. In dition to the supply of some source of energy, a suitable tempera-e, the presence of phosphate, and a supply of basic material, such calcium carbonate, are necessary for the successful operation of rogen fixation process.

"Even under the most favourable circumstances for nitrogen ation, there occurs a period during which adverse processes ne into play, and it is not advisable that a crop be introduced ore these have run to completion."

These conclusions are based on longer experience and therefore a firmer basis. Our experiments though not yet completed firm the conclusion that nitrogen is fixed in soil and in sand with er glucose, sugar or filter paper as the source of energy. We e however found that the nitrogen fixed in this way does not ify within four weeks, *i.e.*, no increase in the amount of nitrates ly present in the soil is obtained within four weeks. It is er observation whether the nitrogen fixed by the bacteria will be ified afterwards and also when it may become available. We e further observed in pot experiments that part of the nitrogen d by the nitrogen-fixing bacteria with glucose as the source of gy is in a form capable of being absorbed by plants without the rvention of nitrifying bacteria.

Although it may be taken as definitely proved, therefore, that ogen fixation occurs with green manure residues in the soil, it worth while to examine the cause of the slow nitrifiability the un-nitrified nitrogenous material as this is likely to throw e light on the non-nitrification of nitrogen in stems and roots. constitution of the nitrogenous material in question may be gned as the probable reason of this slow nitrification, each l of nitrogenous material being assumed to have a different ifiability.

Some experiments were, therefore, undertaken on different kinds of nitrogenous materials. The evidence obtained so far does not support the idea of difference in nitrifiability, as none of the substances tested showed any variation from one another in this respect, and unless some substance showing a different nitrifiability is actually found any explanation based on this possibility will be unsupported. Attention was, therefore, next directed to find out whether the non-nitrogenous material in the undecomposed tissue has any influence on nitrification as this undecomposed tissue which does not nitrify quickly is largely composed of cellulose and woody tissue, and as stems and roots which do not nitrify also contain a greater proportion of cellulose and lignin than the more easily nitrified leaves, we proposed to ascertain what effect some of the non-nitrogenous materials have on nitrification. Experiments are still in progress. It may be added that this question is rather important from a biological point of view, as although much work has already been done on the subject by others, yet sometimes definite information is found wanting. Among other substances dealt with, sugar, starch, filter paper, cellulose, straw, sawdust resin and gums were experimented with. Some of these are likely to be present in succulent tissue, others in the more woody portion. The results obtained so far indicate that when each of these substances is separately added with either ammonium sulphate or oilcake as the nitrifying material to Pusa soil, accumulation of nitrates is effectively checked as compared with the controls.

It is inferred from this that destruction of nitrates takes place in the presence of these substances. To this destruction of nitrate is probably due the adverse effect on plant growth produced by the application of sugar, starch and hay dust in the Rothamsted experiments when a minimum of interval elapsed between the application of these substances and the sowing of the crop.

It is clear from the above experiments that the failure of green manure to nitrify as in the case of tamarind (*Tamarindus indica*) or parts of green manure such as stems and roots in all the four kinds of green manures experimented with may occur under optimum conditions of moisture and temperature and rate of application.

Of the different parts of green manure, leaves nitrify quickly hile roots and stems practically do not show any nitrification.

Hence it follows (*a*) that most of the immediate effect of green anures is due to the nitrogen contained in the leaves being quickly itrified, and also (*b*) that the effect of a leguminous crop on the cceeding cereal crop is due mostly to the fall of leaves from the guminous crop.

The failure to nitrify so far as ascertained does not depend the nature of the nitrogenous materials. It is probably due to trate reduction occurring in presence of great quantities of non-trogenous materials such as cellulose and woody tissue. Whether is possible to avoid these failures by eliminating the effect of these nstituents or these constituents themselves which adversely affect eater fertility by inhibiting nitrification is a subject for further quiry; but it should be borne in mind that this cellulose and ody tissue is very likely to serve as a source of energy to nitrogen-ing bacteria such as Azotobacter and thus ultimately prove an lirect source of nitrogen, and to the nitrogen fixed in this way residual effect of green-manuring and the effect of root residues the leguminous crop on the succeeding cereal may possibly be ribed.

The paper was followed by a good discussion, the substance which is given below :—

Dr. Gilbert J. Fowler.—In my view the author is really asuring in his experiments the resultant of a number of reactions. is well known that under aerobic conditions the only method by ich cellulose is broken down otherwise than by the action of tain moulds, etc., is by the reduction of nitrates. The rapidity this denitrification would depend, as the author's experiments icated, on the character of the cellulose present. With a resist- form of cellulose, *e.g.*, the skeleton of leaves, the nitrate formed oxidation of organic nitrogen might be absorbed by the plant ore denitrification could take place. With less resistant cel-ses the reverse might be the case. It is worthy of suggestion ther some form of silage of green manures under controlled

conditions, preliminary to their application to the soil, may not to nitrogen economy. It may also be pointed out that while the presence of carbohydrate material is favourable to denitrification it facilitates nitrogen fixation.

All these factors have to be separately considered and, if possible, separately studied.

MR. B. C. BURT.—Some results obtained with leguminous crops grown on drain-gauges at Cawnpore suggested that it might often happen that the effect of the roots of green crops was out of all proportion to the amount of nitrifiable matter that they left in the soil. In these experiments, one gauge carried a crop of sann-hemp (*Crotalaria juncea*) during the monsoon, which was removed green in September and followed by wheat in October; the control gauge was fallow in the rains and carried a wheat crop in the cold weather. Although the addition of organic matter was small, the accumulation of nitrogen in the sann-hemp gauge was most marked. The conditions were admittedly artificial owing to the fact that the false bottoms of the gauges provided for thorough aeration as well as ensuring drainage, but the results were suggestive and experiments under field conditions were now in progress.

In respect to green-manuring I deprecate too much limiting of attention to the amount of nitrogen added to the soil by means of green manures. Experience at Cawnpore suggested that the effect of the green manures on the physical texture of the soil was of the greatest importance, whilst, on the other hand, unless drainage and aeration and soil texture generally were right within fairly definite limits, green-manuring was frequently not successful.

MR. R. D. ANSTEAD.—In considering any work on this subject it is always difficult to correctly interpret the results obtained. There are so many factors, some pulling one way and some another—chemical factors, biological factors, climatic factors, physical factors, each having some effect—that it is difficult to grasp what any particular result really means. During this Congress we have also been told of colloidal factors, and now we have a possible inhibiting factor

It seems to me that what is needed is an attempt to determine e critical factors of what must be a complicated reaction or ries of reactions and to isolate these, if possible, and determine e effect of each. Only then shall we able to rightly interpret sults.

The work which I have been doing for many years leads me to lieve that we are apt to bow down too much to the fetish of guminous green dressings. I find that plants which are non-legunous, other things being equal, are very often just as good and ve quite as good results in rich soils so that it is not entirely the rogen content which has to be considered. The great value of the guminous plant lies in the fact that it can often be grown sucssfully as a cover crop on a soil poor in organic matter to begin with here in fact it is badly needed, for example on laterite. By means f the bacteria-containing nodules it is able to obtain the nitrogen requires for its growth from the air. But it must be rememered that there is a great deal of evidence to show that in rich ganic soils the leguminous plant does not develop large quanties of nodules, being able to do without the help of the bacteria d to get sufficient nitrogen in the ordinary way. On such ils it comes down to the level of the non-leguminous plant, d this is another factor to be taken into consideration in this ork.

A great deal more work remains to be done before any definite ronouncement can be made with safety as to what does or does ot happen when organic manures in the form of green dressings re nitrified in any particular type of soil, and I feel that this work ould aim at discussing the critical factors and their individual fect.

The whole subject is one which might with advantage be taken p and discussed at the sectional meeting of agricultural chemists ich as that to be held shortly at Pusa. Such a meeting might ndeavour to collect and summarize the literature on the subject nd the work which has already been done, and make definite roposals as to the lines on which such work might be continued n the future with the special points to be solved.

Dr. R. N. Norris.—At present, in the study of the decomposition of green manures and other organic manures, there is a tendency to limit attention to the nitrification stage which is after all only the end stage of a considerable number of reactions. I think that more work is needed on the preliminary decompositions involved with a view to ascertaining the nature of the intermediate products and the influence of these on fertility, *e.g.*, humus production, solvent action on mineral matters in the soil, etc.

In Madras, where the chief use of green manures is in connection with paddy, the nitrification stage does not occur, as the fermentation takes place under anaerobic conditions. As Harrison and Subramania Aiyer have shown, the influence here is an indirect one largely resulting from the carbohydrate fermentation, the products of which lead ultimately to the aeration of the crop. Hence, work should not be restricted to the nitrogen cycle only as the carbohydrate fermentation may be of equal importance.

What I advocate, therefore, is a systematic bio-chemical study of the fermentation of organic manures by soil bacteria carried out as far as possible, in a *quantitative* manner and under such varying conditions as may obtain in the soil.

Mr. Joshi replied :—As it would take too long to give a reply in detail to all the questions raised in the discussion I shall refer to only a few. Although a great number of changes are bound to occur on the addition of green manure to the soil, I have chosen nitric nitrogen to represent the difference in decomposition of green manures because addition of nitrogen is one of the important factors involved in green-manuring and nitrates are the end product of a number of changes in the nitrogenous material so added, and also because nitrates, if accumulated in the soil, are likely to have great influence on the crop immediately succeeding the green manure. As pointed out in my paper, it is not so much the nature of the nitrogenous material that influences the accumulation of nitrates but the presence of carbohydrates, and, I think, it is the quantity of substances like cellulose, lignin, sugars and resin rather than their quality which so affects the ultimate result.

So long as different green manures give rise to different amounts nitrates, it is not of material importance whether we say that een manures are differently nitrified, or that green manures act so many sorts of catalytic agents for the nitrification of the inert trogen of the soil, as Dr. Mann suggests. In the end, I may y that I have not altogether lost sight of the other questions ised. Experiments are already in progress to solve some of them d others will receive due attention.

As regards two other points raised by Dr. Fowler, I may add at I have already referred in my paper to the question of nitrogen ation by the carbohydrates which adversely affect nitrate cumulation. The question of "silaging" of green manures has eady been worked out and a modified method of green-manuring s been recommended by Mr. Hutchinson in the *Pusa Research stitute Bulletin No. 63.*

THE BIOLOGICAL DETERMINATION OF THE RELATIVE AVAILABILITY OF DIFFERENT NITROGNEOUS ORGANIC MANURES IN BLACK COTTON SOIL.

BY

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I. Introduction.

The availability of various manures is a very important problem, as all plants depend upon available food material for their nutrition. Necessary food material will be available only when it is soluble in soil water and thus capable of assimilation by the plants.

In former days when methods of soil bacteriology had not developed, the valuation of organic nitrogenous manures was based mostly on the percentage of nitrogen found by chemical analysis. But just as the nutritive value of various feeding stuffs depends more on their available constituents than the total, so also the real value of an organic nitrogenous manure depends more on its available nitrogen than the total amount shown by analysis. It may also be possible (as in the case of feeding stuffs) that a particular kind of organic manure, though found to be valuable to a particular class of soil, may have an entirely different value when applied to a soil of another type. We shall now consider how the availability of various manures can be estimated by biological methods.

It may be admitted that organic manures, when added to the soil, have to undergo physical, chemical and biological changes

fore they reach the plants, and that the last of these changes probably the most important. Although there are various ological changes to which organic matter is subjected in the il, the most important is the decomposition of nitrogenous bstances. Formation of nitrates is the ultimate end product of s biological process. It is for this reason that we have chosen rifiability as a measure of the availability of organic nitrogenous manures.

Lipman and Burges[1] have also emphasized the value of nitri-ability as a standard for comparing organic manures. The method, herefore, which is adopted here to determine the availability of arious manures is based chiefly on the determination of nitrites nd nitrates formed in the soil at different periods after the addition f the manure to the soil.

The value and necessity of such investigations into the relative vailability of various organic manures has been realized by many, nd it has also been suggested by Hutchinson[2] that this and other milar lines of work should be undertaken by agricultural bacterio-gists. Having given a brief outline of the subject, we shall now rn to the experimental side.

II. Experimental.

The different organic manures employed in this experiment, ith their respective organic and nitrate nitrogen percentages, were as follows :—

Number	Name	Total N %	Nitrate N %
1	Karanja cake (*Pongamia glabra*)	4·38	nil
2	Mahua cake (*Bassia latifolia*)	2·55	,,
3	Castor cake (*Ricinus communis*)	3·90	,,
4	Sarson cake (*Brassica napus*)	4·72	,,
5	Tili cake (*Sesamum indicum*)	6·22	,,
6	Undecorticated cotton cake	5·33	,,
7	Tili cake (oil-free)*	6·71	,,

* This cake was employed simply for the sake of comparison. It is not commonly used by the cultivators.

[1] *Cal. Agric. Expt. Station, Bull.* 260.

[2] *Memoirs, Dept. Agric. India, Bacteriological Series*, vol. 1, no. 1.

Sufficient care was taken to use as far as possible materials approximately the same size by passing the finely ground material through a 1 mm. sieve. Instead of adding a definite and uniform quantity of nitrogen to the soil, a fixed quantity of manure, namely, one per cent. of the weight of the soil, was employed. Had this procedure not been adopted, the quantities of manures employed in the various cases would have been very widely different owing to the varying percentages of nitrogen, thus probably interfering with the soil texture and consequently with nitrification.

The soil employed for this experiment was from the Nagpur Agricultural College Farm. This soil is the common type of ordinary black cotton soil as found over large areas in the Central Provinces and Berar and many parts of the Deccan. Its nature will be seen from the following physical analysis :—

	Per cent.
Clay	45·62
Fine silt	21·82
Silt	10·79
Fine sand	4·23
Coarse sand	6·04
Moisture	6·37
Loss on ignition	5·68
Calcium carbonate	0·10
TOTAL	100·65

The soil was sampled in the usual way, and the portion which passed through 1 mm. sieve was used in the experiment.

In the first place determinations of initial moisture, nitrites nitrates, etc., in the soil were made, the results of which are as follows :—

	Percentages on dry soil
Initial moisture	11·1
Saturation capacity	66·6 (as determined by a soil layer of 1 cm. depth)
Initial ammonia	nil
„ nitrates	Slight traces
„ nitrites	nil
„ nitrogen	0·038

Method of procedure. Soil representing 500 grm. of dry soil was mixed thoroughly with 5 grm. of the manure to be tested

d sufficient water (about 30 per cent.) was added to bring the l to the optimum moisture conditions required, *i.e.*, approxi-tely half saturation capacity, allowance being made for the isture originally contained in the soil. Any loss of moisture e to evaporation was made up every week if found to be more n 1 per cent. of the soil weight. The soil was well mixed up and into glass jars with tin covers and incubated for a period of 8 eks at room temperature. As these experiments were carried t during the months of August and September, the room tempera-re was not generally much lower than 30°C. during daytime. nounts of ammonia, nitrites and nitrates were determined fort-ghtly, and only ammonia at the end of the first week. For estimat-g nitrites, nitrates, etc., soil equal to 100 grm. dry soil was taken t and occasionally shaken with water for half an hour. 100 grm. soil to 300 c.c. of water were taken, allowance being made for e water already in the moist soil. The whole soil emulsion was en measured, and half of it was filtered through ordinary filter per, while the remaining half was used for the estimation of nmonia.

In the filtrate nitrites were estimated by the Griess Ilosvay ethod, and the nitrates by the phenol-di-sulphonic acid method. Colours in both the cases were matched in a standardized Lovibond's intometer.

For estimation of ammonia, half the soil emulsion was acidulated with hydrochloric acid and left overnight. After the soil had settled down completely, aliquot quantities of the supernatant liquid were distilled with freshly ignited magnesia, and the ammonia was esti-mated by the usual titration method, N-10 acid and alkali being employed for the titration.

The amounts of ammonia, nitrite and nitrate, as determined by the above-mentioned methods, are given in the table on the next page.

Table showing amounts of nitrogen in milligrams in the form of ammonia, nitrites and nitrates, per 100 grm. of dry soil.

Name of manure	1st week	2nd week				4th week				6th week				8th week			
	N as NH_3	N as NH_3	N as NO_2	N as NO_3	Total % N nitrified	N as NH_3	N as NO_2	N as NO_3	Total % N nitrified	N as NH_3	N as NO_2	N as NO_3	Total % N nitrified	N as NH_3	N as NO_2	N as NO_3	Total % N nitrified
Karanja cake ..	7·90	8·80	traces	0·77	1·75	4·48	5.35	16·01	36·38	1·12	sl. tr.	28·18	64·04	1·12	nil	28·18	64·04
Mahua cake ..	0·50	1·68	nil	nil	0·00	1·12	nil	nil	0·00	0·56	nil	nil	0·00	1·12	,,	nil	0·00
Castor cake ..	9·94	10·08	traces	0·77	1·97	7·28	6·43	6·40	16·39	0·56	,,	28·18	72·25	1·12	,,	25·62	65·69
Sarson cake ..	11·42	9·32	,,	0·77	1·63	5·60	6·85	9·60	20·42	0·56	sl. tr.	25·62	54·51	0·56	,,	25·62	54·51
Tili cake ..	21·40	19·04	0·75	1·02	2·84	10·08	9·85	10·25	16·53	1·12	,,	35·86	57·83	1·12	,,	40·99	66·11
Undecorticated cotton seed cake.	11·80	13·44	1·28	1·54	2·90	3·92	0·76	20·35	38·39	2·80	nil	32·02	60·41	1·68	,,	35·86	67·66
Oil-free *tili* cake	20·92	22·40	0·75	6·40	9·55	14·00	9·42	11·53	17·20	1·68	slight traces	43·55	65·00	1·12	,,	49·95	79·28

The total percentage nitrogen nitrified, referred to in the last column of the above table, includes *both* nitrite and nitrate nitrogen.

Various facts can be ascertained from the foregoing table, l the results can therefore be individually examined for each nure separately.

Karanja cake. This cake appears to be very susceptible to rification. Two important features are noticeable about this nure—one is the absence of such high concentrations of ammonia the soil as are found with cotton and *tili* cake; and the other the rapid formation of nitrates which is not experienced in any the other manures except cotton cake. In this case as much as per cent. of the nitrogen is converted into the form of nitrates the end of fourth week as against 16 per cent. with castor and cakes and 20 per cent. with *sarson* cake.

Mahua cake. This cake seems to be very peculiar in that it is ot nitrified at all even during a period of 8 weeks. The nitrogen this manure appears to be resistant to the action of soil micro-rganisms, thus totally excluding *mahua* cake from consideration s an active organic manure. Ammoniacal decomposition also eems to be tardy in operation in this case, and it amounts to practially nothing even after a period of 8 weeks. In order to further lucidate this problem of ammoniacal decomposition, a special xperiment was conducted as follows :—

A quantity of *mahua* cake, containing 60 milligramms nitrogen, as added to a solution of sodium chloride before or after the various reatments as detailed below, and the whole was then sterilized. he mixture was then inoculated with 1 grm. of black cotton soil nd incubated for a period of 8 days. Afterwards the amount of mmonia formed was determined by the usual magnesia method. n order to compare the results of this experiment, another set of olutions containing *tili* cake instead of *mahua* cake was employed.

The treatment of the cake was as follows :—

1. *Mahua* cake (containing 60 mg. N), plus 100 c.c. 0·5 er cent. sodium chloride solution, plus 1 grm. black cotton soil incubated without any treatment).

2. *Mahua* cake as above, but heated up to 120°C. dry heat n a sterile flask, plus 100 c.c. sterile 0·5 per cent. sodium chloride olution added afterwards, plus 1 grm. black cotton soil.

3. *Mahua* cake plus 100 c.c. 0·5 per cent. sodium chloride solution (both sterilized at 130°C. moist heat for 15 minutes) and then inoculated with 1 grm. black cotton soil.

The amounts of ammonia formed after a period of 8 days out of 60 mg. nitrogen originally contained in the material were as follows :—

	Mahua cake	*Tili* cake
1.	0·07 mg.	25·90 mg.
2.	0·42 „	29·40 „
3.	0·42 „	30·10 „

From the above experiment, it is seen that the ammonification of *mahua* cake does not take place at all quickly, and at the same time artificial treatment, such as dry and moist heat, does not help it in any way. Hence nitrification appears to be impossible within a period of at least 8 weeks. Whether it is nitrified at all or not after a very long period is not yet ascertained, but, as a manure, *mahua* cake cannot be classed with the other commonly occurring cakes.

Why this material should not readily decompose in the soil, and what treatment is possible to bring it into a suitable form for quick bacterial action, are problems under investigation.

Castor cake. This cake appears to be as quickly decomposing a manure as *karanja* cake, although in the beginning a lower percentage of nitrates was found.

Sarson cake. This cake seems to be the slowest in decomposition of all except *mahua*, at least so far as its nitrifiability in black cotton soil is a guide.

Tili cake. This is more or less on the same level as *karanja* castor and cotton cakes as regards the total percentage of nitrogen nitrified, but it is not as rapidly nitrifiable as *karanja* and cotton cakes. Accumulation of ammonia seems to be higher during the first 4 weeks in this case than with *karanja* and cotton cakes.

Cotton cake. This seems to be more or less similar to *karanja* cake in every respect.

Tili cake (*oil-free*). Considering the total percentage of nitrogen nitrified, this cake is the best of all. High concentration of ammonia and nitrites, however, takes place with oil-free *tili* cake to a

eater extent than with the other manures under investigation. he total quantity of nitrogen nitrified goes as high as 79 per cent. against 0 to 67 per cent. in other cases. The fact that the removal oil from oilcake increases the rate of nitrification has been observed other occasions also. Whether the costly process of removing l from oilcakes would in the long run be economical merely from a anurial point of view is doubtful, particularly when it is considered at cakes from hydraulic presses do not contain sufficient oil to riously retard decomposition. Machine-pressed cakes for manu- il purposes will, however, be distinctly more advantageous than ose obtained from a country *ghani* (mill), as the oil is far more mpletely removed in the case of the former.

III. Summary.

1. The relative availabilities of the common oilcakes used manure have been determined by considering the rate at which nitrogen they contain undergoes bacterial transformation.

2. The soil used in the experiments was the common black tton soil of the Deccan.

3. Excluding oil-free *tili* cake, *karanja* and cotton cakes pear to be by far the most quickly available, and castor cake not much inferior to them.

4. *Tili* cake is not quite so active, although the nitrogen timately nitrified compares favourably with that of other cakes.

5. Of the various manures used in this experiment, with the ception of *mahua* cake, *sarson* cake is the slowest so far as its trifiability in black cotton soil is concerned.

6. The nitrogen in *mahua* cake is neither ammonified nor trified to any appreciable extent during a period of 8 weeks.

A STUDY OF THE CONDITIONS UNDER WHICH WATER OF TIDAL SALINE CREEKS IS UTILIZED FOR CROP PRODUCTION IN KONKAN.

BY

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A PRACTICE of using waters of the saline river creeks for growi some of the commonly cultivated crops has come to the notice of t writer in Konkan.

With a view to clearly understand the conditions under whi this is done, and thus to find out the possibilities for the extensi of the practice, a detailed study of the question was taken u The results which the enquiry has led to are of some scienti interest, since they seem to take us some way further in our existi knowledge about the resistance of agricultural plants to the salini in the water they have to live on; besides, a good scope is al indicated for the extension of the practice to newer areas, whe it is not known at present, but where the conditions may be foun suitable. The object of this paper is to record the informati which has been collected and the findings which have been arriv at on the subject.

The practice attracted my attention first early in the ye 1916, when I was touring along the Savitri river creek (Bank Mahad creek in the Kolaba District of the Konkan), where succe ful crops of brinjal (*Solanum melongena*) were seen growing with t exclusive help of the water from the section of the creek betwe

gaon and Mahad, *i.e.*, about 20 miles higher up in the interior n the mouth of the river where it joins the Arabian Sea. Enquir- agricultural, chemical and geographical—have since been in gress, and it has been possible to-day to fairly define the condi- s under which the practice of growing some crops with the help the saline water is followed.

DESCRIPTION OF THE TRACT UNDER OBSERVATION IN RESPECT TO ITS CREEKS AND CREEK SIDES.

Before describing the conditions in detail, it would be desirable briefly summarize the physical features of the area under enquiry, ecially in relation to its rivers and creeks. The study of the stion has so far been confined to Konkan, *i.e.*, that part of the nbay Presidency stretching along between the west coast of the abian Sea and the Western Ghats, and comprising of the four tricts of Thana, Kolaba, Ratnagiri, and Kanara (excluding the up- at portion). It receives heavy storms of rain measuring 100 inches more in a very short period of four months of June to September. is hilly and much traversed by rivers of more or less size, which, ing in the Ghats, take their course more or less westwards across breadth until they join the Arabian Sea, by short drainage nnels which form the tributaries of the large rivers and by kwater channels. The water from the sea rises back in these ter lines at high tides to more or less distances according to the gth and the fall of the courses, in large rivers going as back as to 35 miles from the sea ; above this point they are sweet water eams, which greatly diminish in their size, in some cases almost nil, as the fair season advances. For about 15 to 20 miles from ir mouths the creeks wind between low-lying plains on either e, which are permanent marshes or reclaimed salt rice lands, in comparatively flat and open country of the Thana, Kolaba and nara districts, or between deep gorges formed by the slopes narrow valleys of the Ratnagiri District. Higher up, towards high tide water limit and above, however, their courses in h cases lie between steep banks five to ten feet or more above water-level, which stretch more or less wide and flat, or gently

sloping if at all away from the bank; these belts of upland submerged at high floods of the river during the rainy sea and receive deposits of fine silt; these are called *malkhandis* (silt, *khand* piece), and are usually deep, fertile and retentive moisture and grow fine dry crops of *tur* (*Cajanus indicus*) and se mum (*Sesamum indicum*) in the *rabi* (winter) season; on sufficien high banks which are less liable to submersion, even *kharif* cr like *nagli* (*Eleusine coracana*), *vari* (*Panicum miliaceum*), and nig seed (*Guizotia abyssinica*) are grown.

Factors determining the successful growth of certain crops with saline waters.

Degree of salinity which the crops cultivated can withstan Now, coming to the describing of the determining factors, t first that may be considered is the degree of salinity of the wat which is actually being successfully used for the growing of certa crops. It is the common belief that the waters of the creeks, described above, are quite sweet up to within a few miles to the se during the monsoon, owing to the very large volumes of sweet wat from the characteristic heavy rains of Konkan flowing into the and after the monsoon they acquire more and more salinity in stag as the fair season advances and as the volume of sweet water dim nishes, until at last they are considered to be quite unfit by about t middle or the end of February. The character of the past rain season is believed to advance or retard the acquisition of salinity thus a year of deficient rainfall as the current (1918) year, or eve too early cessation of rain is asserted to bring on salinity earlie In order to verify this belief and to measure it in definite term samples of waters taken at the time of each watering that was give to a crop of brinjal (*Solanum melongena*) throughout its growi period from the creek of the river Amba near Nagothna (Kolab District) were analysed for their salt contents through the kindne of Dr. H. H. Mann, Agricultural Chemist to the Government of Bombay; the results are set out in the following table:—

Description of the sample	Total salts	Containing: Sodium chloride	Calcium carbonate	Calcium sulphate	Magnesium sulphate	Magnesium chloride	Magnesium carbonate	Remarks
			Parts per	100,000	of water			
Water from creek near Mahad on which crops grow, taken on 11– 1–1917	52·00	36·96	5·81	..	..	..	..	Excellent irrigation water (Dr. H. H. Mann).
Water from creek near Bandsa (Nagothna) 11– 1–1917	764·00	612·15	15·49	..	..	..	..	Useless (Dr. H. H. Mann).
Do. Nagothna .. 17–12–1917	52·00	24·42	9·68	3·06	0·37	8·32	..	
Do. ,, .. 27–12–1917	30·00	3·39	11·62	0·34	6·90	6·64	..	
Do. ,, .. 31–12–1917	112·00	69·46	11·62	0·34	7·90	9·29	..	
Do. ,, .. 5– 1–1918	118·00	70·69	10·00	..	8·20	12·19	0·28	
Do. ,, .. 9– 1–1918	174·00	111·11	14·00	..	13·32	15·40	..	
Do. ,, .. 17– 1–1918	878·00	673·85	28·00	..	4·10	65·06	32·26	
Do. ,, .. 25– 1–1918	820·00	567·77	12·42	29·39	44·87	78·47	..	
Do. ,, .. 2– 2–1918	836·00	582·84	12·42	21·14	56·17	66·19	..	
Do. ,, .. 10– 2–1918	840·00	646·55	12·42	15·70	59·92	56·69	..	
Do. ,, .. 24– 2–1918	856·00	634·19	20·70	15·30	69·05	66·70	..	
Do. ,, .. 28– 2–1918	2120·00	1442·51	20·70	80·58	114·45	196·08	..	
Do. ,, .. 15– 3–1918	2732·00	1906·92	18·63	68·65	180·05	203·28	..	
Sample of *salt water* from rice plots, Larkhana, Sind, which is supposed to be the strongest that rice crop can withstand (October 1918).. ..	940	742·50	5·17	63·68	43·56	..	Potassium chloride.	Kindly supplied by Mr. V. A. Tamhane, Acting Agricultural Chemist to the Government of Bombay.
AVERAGE SEA-WATER ..	3500	2653	..	161	196	318	129	

It will be seen that the above analytical results are sufficient to bear out the popular belief and clearly establish that up to the end of December creek waters from the sections where they were taken, *i.e.*, about 27 miles away from the sea and about 7 miles lower than the highest limit of tide water, are tolerably sweet and fit to sustain crop growth, and that after that time they get more saline and remain so for two months, while by the end of February the salinity suddenly increases to as much as about three-fourths of the salinity of the average sea-water. Another noteworthy point that can be deduced is that the salinity from the middle of January onwards is more than the limit which might be ordinarily considered as the strongest that ordinary crops or even rice, the most resistant of the crops known, were so long known to withstand. The enquiry, however, reveals that certain crops as are at present cultivated can, as is actually the case, withstand even larger degrees of salinity.

Next, in order to find out how far and under what physical and other conditions and circumstances similar practices do or do not obtain on creeks of the four Konkan districts, some typical and important creeks representative of each of the four districts were surveyed. In the Thana and Kanara districts the practice is unknown; the reason given is the ignorance of how such a thing could be possible. In the Kolaba District, on the Revdanda-Roha creek, the cultivators do not take any crops, though they know the fact that their neighbours at Nagothna on the Dharamtar creek use the saline water for raising certain crops. But on the remaining important creeks of the Kolaba District, and almost all the large creeks of the Ratnagiri District, the practice appears to be generally known and in vogue in particular sections of the creeks as described hereafter.

Parts of the creek which are considered and found suitable.—The distance from the sea to which the high tide reaches on large creeks in Konkan is generally 25 to 35 miles as has already been said above. It was uniformly observed on all creeks that use of the saline water for crop production is generally confined to the large creeks and its tributaries, and to such sections on them as l

hin the last 8 or 10 miles of the tidal limit along which there are ks. with deep, well-drained soils, and high enough as not to be merged by tidal waters, but not too high (up to about 10 feet) to ke water lifting prohibitively costly.

The reasons for the absence of any similar cultivation of crops h saline waters along the lower parts of the creeks are stated be two :—The first and the most common and likely is that the ters in the lower sections as the sea is approached get more and re saline and that too earlier than at the sweet water ends. ondly, along the low-lying creek side plains of Thana and Kolaba eks, there are no suitable lands close by the waters, on account their being either marshes or reclaimed salt rice lands which are ieved to be containing already an excess quantity of salt. Along creeks in the Ratnagiri District, however, the second condition s not prevail, the hill slopes edging the creek waters and affording least some good land fit for cultivation ; but even here no saline ter cultivation is thought of.

Both these points require further investigation by actual lyses and trials.

Crop found suitable. Brinjal (*Solanum melongena*) is by far commonest crop which is cultivated under the above conditions. llies (*Capsicum frutescens*) is the next one in importance, not ng however considered as resistant to salt as brinjal ; castor *cinus communis*), sweet potatoes (*Ipomea batatas*) and maize *a Mays*) sometimes are seen to occupy the borders, odd corners as a sprinkling in the main crops of brinjals and chillies. There no special varieties of these which are recognized as particularly table for cultivation on saline water. In Kanara District, a itary instance of the creek water being used for irrigating young onut seedlings in the months of April and May without any parent harm to them was noticed at Hedge in the Kumta taluka.

Method of cultivation. Sites having suitable soil and level lds at points where they would be edging the water of the creek d the lift would be small are usually selected for cultivation, so t the lift and lead of the water would be as little as possible. October, after the monsoon rains cease, the soil is broken up

by a plough and further pulverized by the breaking of clods with mallets, and is thus thoroughly prepared to a depth of 6 to 8 inches. If there be not enough moisture in the soil, it is wetted by pouring water in small patches at from 2 to 3 feet apart each way. In this wet soil holes 3″ to 4″ deep are bored with a peg or a stick, and seedlings are inserted in these holes and soil pressed over. No manure is generally used, but occasionally those who have any farmyard manure to spare do give it to each plant at the time of planting; some people put water mixed with fresh cattle dung in the hole before planting; another dose of farmyard manure is again given by some if available at the time of earthing up. The crops are not, however, taken continuously in one and the same place for more than one to three years according as they are nearer to, or further from, the sea, as it is supposed that the soil becomes salt sick after that period.

Irrigation. Irrigation is begun and continued as required. For the first week after transplanting, hand watering is done twice a day, after which it is done once a day for about a week more, and on alternate days for another week. It is considered necessary by practical men that the water given to the newly transplanted seedlings must be sweet until they take root and establish: ordinarily the water in the sections of the creeks where the cultivation is practised, is sweet at the time of transplanting in the middle of October, but if for any reasons it should happen otherwise, sweet water from some other source has to be provided.

If the soil is fairly retentive, no water is given until the flowers begin to appear by the end of November as on the Vashisti river (Chiplun, District Ratnagiri) creek. After this some kind of water lift is set up and irrigation given every four to six days or more up to the middle of February, and thereafter for a month more at an interval of about a fortnight. In some cases it is also found that plants are watered on four consecutive days from the 10th to the 14th of each lunar half, the reasons being that more labour is required from the 4th to 9th for lifting the water, which rises but very moderately on these days, and on the 15th, 1st, and 2nd there is more salinity in the water.

After this, the creek water getting too saline, watering is stopped nd the plants are allowed to grow on residual soil moisture, on hich they thrive and continue to bear till the end of the hot weather; ases have also been noticed where brinjal plants, after thus surviving rough the hot weather, take on fresh vigour on the commencement the monsoon, and continue to bear until they are killed by the ods.

The extent of the salinity which the creek waters acquire different times of the season and at points where crops are grown n be seen from the statement given above.

In the latter part of the season a distinct incrustation of salt visible on the surface of the land.

The time of irrigation is generally chosen at the high tide, when e level of the water in the creek naturally rises and the lift and e lead are thereby reduced. No difference, however, is recognized tween the high tide and the low tide water, as regards its suitabi-y or otherwise for crop growing.

The water lift most commonly used is *Okti*, the counterpoise ucket lift worked by hand, though on one creek in the Ratnagiri istrict Persian wheel is also used; where the area to be cultivated s small, watering by *gharas* (earthen vessels) is resorted to.

Further care and outturns, etc. The only other care that the rop requires besides the above is earthing up, fencing, watering nd harvesting. The first and the heaviest picking of fruits is btained in the months of January, February and March, yielding noderate pickings; from April onwards only small pickings are btained, the fruit borne diminishing in size and contracting in the ase of brinjals an acrid taste. The outturns are by no means less han those obtained under ordinary methods of cultivation with sweet water; the quality is also said to be as good as that from the sweet water.

CONCLUSIONS.

Creek waters are mostly sweet during the monsoon, are tolerably so till the end of December, and after that time this salinity increases to an extent which would have so long been considered as unfit

for the ordinary agricultural plants, but which it is found can safely be used for growing very successful crops of brinjal and chillies till the end of February. After this they get too saline to be used without harming the plants watered.

2. According to the information which has been made available so far, it is only in the last eight to ten miles below the point to which the high tide reaches that such crops can be grown.

3. There are yet many situations in the Ratnagiri and Kolaba districts where the practice is already known, and in the Thana and Kanara districts where the practice is altogether unknown, in which the cultivation can be extended and introduced with great advantage. The crop of chillies, which can be turned into a durable product, and which is an article of every-day diet of the Indians, presents a better scope than brinjal, which is of a perishable nature. Perhaps other parts of India and those of the world where conditions may be suitable may benefit by the information recorded in this paper.

4. It might be ascertained by analysis and actual trials if creek water in the lower sections cannot similarly be used for growing any crops. Similarly, several other agricultural plants, especially those which are known to be salt-resisting to some extent, might be experimented with, with a view to find if any new or more profitable crops cannot be added to the present list. This would be made a subject of future study.

PRELIMINARY NOTE ON SOME NEW FACTORS AFFECTING THE HARDNESS OF *GUR* OR CRUDE SUGAR.

BY

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It is a matter of common knowledge that hardness in *gur* (crude sugar) is an essential factor in the successful storage of it through the monsoon.

It is often pointed out that the factors affecting this hardness or keeping quality arise mainly in the *gural* (boiling) house and they are attributed to one or the other of the following :—

(1) Ripeness of the cane.

(2) Milling, clarification of the juice and its boiling.

(3) Cleanliness in the boiling house.

(4) Lodging of the canes.

But from observations made in the Gokak-Hukeri tract of the Belgaum District, I have come to the conclusion that these are not *all* the factors, but there are some more which are equally, if not more, important.

In the tract referred to above, there has been a longstanding belief among cultivators that the hardness or keeping quality of *gur* is dependent on the conditions of soil and water, over and above the essentials in the boiling house. This idea seems to be equally prevalent among the merchants who store the product. By experience they are able to give a list of the places which are noted for this good quality in the *gur* as well as of such localities which

do not produce the right kind though the details of cultivation, manuring and manufacture are practically the same.

With a view to rectify the defect and to meet demands from cultivators, expert *gur* boilers were sent, from time to time, to these places, but the measure of success attained was small.

I had, therefore, to investigate into the subject on a systematic basis. The lines on which I proceeded and the details I collected can best be seen from the statement attached (Appendix I).

In making the tests, I have, as far as possible, avoided the lodged plots and tried to obtain uniformity in the other factors hitherto supposed to affect the glucose ratio and hardness, such as ripeness, manuring, boiling, etc. But it is interesting to note from the statement that, wherever there has been a variation in the soil or water, the hardness has been affected.

In fact, grey soil and brackish water tend to make the *gur* soft and fluid. In one instance, *viz.*, test No. 1 in the statement, brackish water from a well was used for irrigating the sugarcane crop and the *gur* turned out was soft and sweaty. But during the year of my enquiry, sweet water was available during nine months and the resulting *gur* was of better quality.

All these data, I think, should prove that soil and water have also an important bearing on the hard formation and keeping quality of the *gur*.

That salts enter into the composition of *gur* in varying proportions, there is clear evidence to prove from the chemical analysis. The salinity is distinctly marked even to the taste some *gur* tasting very sweet, others saline. It is the salt in the brackish water and grey soils that must be responsible for the mischief. Whether it is the intrinsic hygroscopicity of the salts that affects the hardness or whether any change is brought about in the glucose ratio of the *gur* has yet to be studied.

To corroborate my observations in the field, I had samples of *gur*, soil and water sent for analysis to the Agricultural Chemist, Poona; his letter and the results of analysis are quoted below (Appendices II, V and VI).

As the Acting Agricultural Chemist remarks, no doubt, a larger number of samples are required to come to a final decision. However his results of analyses of the few samples sent indicate that waters used for irrigation contained varying proportions of alkalinity which are paralleled in a more or less similar ratio by the composition of the resulting *gurs* as well as their hardness.

Again, if we look into the glucose ratios of the bad, sticky samples analysed, they are not bad enough to make an ordinary *gur* very soft. But, as these samples are very soft and sticky, the argument goes to support my observations.

In conclusion, I must admit that there are shortcomings in my paper and I am aware of them. For instance, the Brix readings recorded (Appendix I) cannot be wholly reliable unless the purity of the juice is ascertained. But these and similar defects I could not help for want of a laboratory on the farm.

It is my intention, however, to tackle the subject more soundly next year and to present a complete paper.

Statement showing the details of information collected in connectio

Tal

No. of enquiry	Survey No.	Name of village	Kind of soil	KIND OF MANURE USED FOR THE SUGARCANE CROP: Farm-yard manure	Sheep-folding	Top-dressing	WATER USED FOR IRRIGATING THE SUGARCANE CROP: Sweet	Saline	Date of planting the sugar-
1	2	3	4	5	6	7	8	9	10
1	69	Ammangi	Light red coloured	Farm-yard manure.	Sheep folding.	..	......	Brackish	5-3-1
2	68	,,	Grey coloured	,,	,,	..	... ..	Very brackish	,,
3	262	,,	Reddish brown	,,	..	...	Very sweet	... ..	,,
4	16	Masarguppi	,,	..	..	...	,,	...	8-3-1
5	1	,,	,,	..	..	...	,,	...	10-3-1
6	9	,,	Black grey	..	..	...	,,	...	17-3-1
7	380	Mannolli	Light grey	..	..	..	Sweet	...	10-3-1
8	477	,,	Black	..	..	...	Very sweet	...	15-3-1
9	375	,,	,,	..	..	..	,,	...	,,
10	389	Nerli	,,	,,	,,	...	,,	...	8-3-1
11	179	,,	,,	,,	,,	...	,,	......	,,
12	19	,,	Light black	..	..	...	......	Brackish	9-3-1
13	14	..	,,	..	..	Oil-cake and Am. sulphate	Sweet	... ..	30-3-1
14	14	,,	Black grey	,,	..	...	,,	...	,,
15	17	,,	,,	..	..	...	,,	...	,,
16	283	Mannolli	Black	,,	..	...	,,	......	4-4-17
17	288	,,	Medium black	..	..	..	......	Brackish	8-4-17
18	108	Ammangi	Black	..	..	...	Very sweet	... ...	28-3-17
19	110	,,	,,	..	..	.	Sweet	...	25-3-17
20	55	Nerli	,,	,,	..	...	Very sweet	...	15-3-17
21	99	Hebal	Sandy	,,	..	...	,,	...	24-3-17
22	182	Nerli	Black	..	..	...	,,	...	24-3-17
23	183	Ammangi	,,	,,	,,	...	,,	...	9-3-17
24	119	Gotar	Light black or grey black	..	..	..	Sweet	...	17-3-17
25	113	,,	Black	..	..	.	Very sweet	...	10-3-17
26	103	Hebal	Black grey	..	..	..	... ..	Brackish	24-3-17
27	3	Kochri	Brown black	..	..	..	Very sweet	...	8-3-17
28	25	Gawnal	Black	..	,,	...	Sweet	.....	22-2-17
29	38	,,	Grey black	..	..	,,	,,	.	,,
30	144	Gotur	Black	,,	..	...	..	.	8-3-17
31	42	Kochri	,,	..	..	...	,,	..	7-3-17
32	46	,,	Alluvial	..	..	...	,,	...	21-2-17
33	39	,,	Black	..	..	...	Very sweet	.	
34	32	Gawnal	,,	..	,,	...	,,	......	25-2-17
35	45	,,	,,	,,	,,	...	,,	.....	28-2-17

he causes affecting the keeping quality of Gur *in parts of the Hukeri*
istrict.

of the crop of harvest	Brix reading corrected	Temperature recorded at the time of striking the boiling pan	Remarks about the cleanliness in the boiling or *gurhal* house	Kind of fuel used	Colour of *gur*	Reputation for the hardness or keeping quality of *gur* in the locality
12	13	11	15	16	17	18
ly lodged	17	120° Centigrade	Fair	Dried stalks of *tur* and chillies and megass	Black	Usually the *gur* from this field is soft but only this year on account of the crop receiving sweet water from a stream for 9 months, the *gur* is fairly good.
"	16·0	122°	..		"	Soft and sweating.
anding	18·0	120°	..		Red yellow	Good.
"	16·0	122°	..		Green red	"
"	17·5	120°	..		Red yellow	"
tly lodged	16·5	120°	..		Greenish	Good but sweating in the rains.
tanding	17·0	121°	.		Brown	"
tly lodged	16·5	120°	..		Red yellow	Very good.
tanding	17·5	120°	..		"	"
tly lodged	15·0	120°	..		Reddish	Fairly good.
tanding	18·5	120°	..		Red yellow	Very good.
tly lodged	15·5	122°	..		Black	Soft and sweating.
tanding	17·5	120°	.		Red brown	Fair but sweating in the monsoons.
"	16·0	122°	..		Black soft	Soft and sweating.
"	16·5	120°	..		Greenish black	Fairly good in the fair season.
"	15·5	120°	"		Red brown	Fairly good.
"	16·5	122°	..		Green black	Soft and sweating.
"	17·5	120°	..		Green red	Good.
"	17·5	120°	..		Green yellow	Very good and heavy.
Lodged	16·0	121°	..		Brown black	Fairly good but sweating in the monsoons.
tanding	15·5	119°	"		Green yellow	Very good and heavy.
"	18·0	119°	..		Yellowish green	"
"	17·5	119°	..		"	"
tly lodged	15·5	121°	..		Brown black	Fairly good but sweating in the rains.
tanding	15·5	119°	"		Reddish green	Fairly good and heavy.
"	15·5	121°	..		Brown black	Bad.
"	17·5	119°	"		Reddish yellow	Very good and heavy.
in a few places	15·5	Not recorded	..		Yellow red	Very good.
Standing	15·0	..	"		Red brown	Good but sweating in the monsoons.
"	15·0	"	..		Yellow	Fairly good.
"	17·5	"	..		Red brown	"
"	18·5	"	..		Green yellow	Very good and heavy.
Lodged	14·0	..	..		"	Very good for keeping but not heavy.
Standing	16·5	"	"		Green red	Very good.
"	16·5	"	..		Red brown	Fair.

APPENDIX II.

Analysis of water samples used for irrigation in the case of the Gurs shown in Appendix III.

	Water No. 1	Water No. 2	Water No. 3	Water Nos. 4 and 5
Total salts	40 000	101·00	92·00	These were lost ... way.
Containing :—				
Calcium carbonate	14·00	18·00	26·00	
Magnesium carbonate	9·08	19·74	2·48	
Magnesium sulphate	...	7·17	12·30	
Magnesium chloride	...	6·37	20·25	
Sodium bicarbonate	5·32	...	...	
Sodium sulphate	2·44	...	..	
Sodium chloride	4·52	43·06	7·47	

N. B.—The Serial Nos. correspond to those in Appendix III.

APPENDIX III.

Analysis of samples of different kinds of Gurs.

	Gur No. 1	*Gur* No. 2	*Gur* No. 3	*Gur* No. 4	*Gur* No. 5
	Solid lighter yellow	Soft and sticky dark black	Sticky semi-solid dark to red	Solid and hard darker	Solid and hard darker
	%	%	%	%	%
Moisture	4·88	6·58	7·66	3·36	3·88
*Ash	1·08	1·46	1·54	1·54	1·56
Glucose	7·53	9·60	7·36	4·73	5·09
Sucrose	77·90	79·04	75·18	87·38	84·94
Glucose ratio	9·66	12·14	9·78	5·41	5·99
Alkalinity calculated as :—					
Sodium carbonate ...	0·010	0·042	0·063	nil	0·010
Carbonate as CO_3 ...	0·147	0·171	0·110	0·100	0·183
Chlorine	0·084	0·252	0·224	0·112	0·112
Equivalent to sodium chloride	0·138	0·416	0·369	0·185	0·185

* Containing in the water solution.

N.B.—These Nos. correspond to those in Appendices II, IV & V.

APPENDIX IV.

tatement giving the details of information about the Gur *samples analysed in Appendix III.*

	Nature of soil on which it is produced	Nature of water used for irrigation	Local reputation about the keeping quality
ur No. 1* ..	Medium black	Sweet	Hard and keeping well.
No. 2* ..	Grey	Brackish	Bad and sweating.
No. 3* ...	"	Slightly brackish	Not good.
No. 4* ...	Brown red	Very sweet	Hard, heavy and keeping quality excellent.
" No. 5* ...	Light grey	"	Fairly hard and keeping.

* There was practically no difference either in the condition or cultivation of the crop or anufacture of *gur* or manuring.

N.B.—The Serial Nos. correspond to those given in Appendix III.

APPENDIX V.

Analysis of soil samples relating to the Gurs *shown in Appendix III.*

	Soil No. 1		Soil No. 2		Soil No. 3		Soil No. 4		Soil No. 5	
	Surface soil	Sub-soil	Surface soil	Sub-soil	Surface soil	Sub-soil	Surface soil	Sub-soil	ace soil	Sub-soi
	%	%	%	%	%	%	%	%	%	%
al soluble salts ...	0·07	0·08	0·C8	0·08	0·08	0·100	0·100	0·080	0·07	0·08
taining :—										
ium carbonate ...	0·025	0·010	0·040	0·030	0·050	0·040	0·030	0·020	0·020	0·030
ium sulphate ...	0·007	...	...	...	...	...	0·013	...	...	...
nesium carbonate		0·015	...	...	...	...	...	0·013	...	0·018
nesium sulphate ...	0·009	...	0·010	0·020	0·010	0·025	0·009	0·013	0·020	0·010
nesium chloride ...	0·026	...	0·009	0·009	0·018	0·013	0·009	...	0·010	...
um bicarbonate ...	...	...	...	...	...	...	...	...	...	...
um sulphate ...	...	0·030	...	...	...	...	...	...	...	...
um chloride ...	...	0·011	...	...	...	0·005	...	0·023	0·011	0·023
nesia in other forms ...	...	...	0·009	0·005	0·007	...	0·010	...	...	...

N.B.—ThesejNos. correspond to those given in Appendix III.

APPENDIX VI.

Copy of D. O. No. 643 of 17th October, 1918.

From the Agricultural Chemist to the Government of Bombay, Poona, to the Superintendent, Agricultural Station, Gokak.

I have been able at last to send you the figures of analysis of the samples of *gur*, soils and waters which you sent to this office with your letter No. 871 of June 14, 1918.

I hope the figures will be of use to you in drawing some definite conclusions as to the causes which affect the keeping quality of *gur*. They must, however, be taken with due regard to such other factors as the condition of the crop at the time of harvest, Brix reading of the juice, effect of manures used and such others as indicated in your D. O. 812, dated June 12, 1918.

If we compare the figures of glucose and sucrose in all the fi samples, we find that Nos. 4 and 5 contain the largest amount sucrose and the least amount of glucose and these two are sol and hard samples. Next to these in percentage of sucrose stan sample No. 2, but the percentage of glucose in it is very high a the sample is soft and sticky. Sample No. 1 contains less sucro than No. 2 but at the same time the percentage of gluco is less and the sample is solid. Sample No. 3 contains near the same percentage of glucose as No. 1 but the percenta of sucrose is very low and the *gur* is a semi-solid stick mass.

If we compare the soluble constituents in the ashes of th different *gurs* we find that Nos. 2 and 3 which are sticky contain th highest amount of alkalinity calculated as sodium carbonate. The two samples also contain the highest amount of chlorine.

If we now compare the analysis of water, we find that sampl No. 1 is decidedly better than either No. 2 or 3 both of which contai too much of magnesium salts and particularly chlorides. These tw waters have been used in the case of the two sticky samples of *gur* *viz.*, Nos. 2 and 3.

As regards soils, I do not think any comparison can be made to ow differences which are likely to affect the keeping quality of different samples of *gur*.

The comparisons made above apply only to the 5 samples of sent but whether they are applicable in the majority of cases is ubtful.

STUDIES IN THE CHEMISTRY OF SUGARCAN

BY

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I. Introductory.

This investigation was taken up, in the year 1914, at Dr. W. Harrison's suggestion.

At the Government Cane-breeding Station, Coimbatore, thousa of sugarcane seedlings have to be tested every year within a co paratively short harvesting season, this requiring the concentra attention of a number of men. If means could be devised to t the seedlings at a comparatively early age, say, when they are ab eight months old, the work of chemical examination and select could be spread over a greater portion of the year, thus avoid abnormally high pressure of work at the ripening season. With t object in view, a series of preliminary experiments were institut The results of these investigations have not yet reached the stage completion, but the subsidiary results so far obtained are of interesting nature, and it was, therefore, thought desirable to publ them.

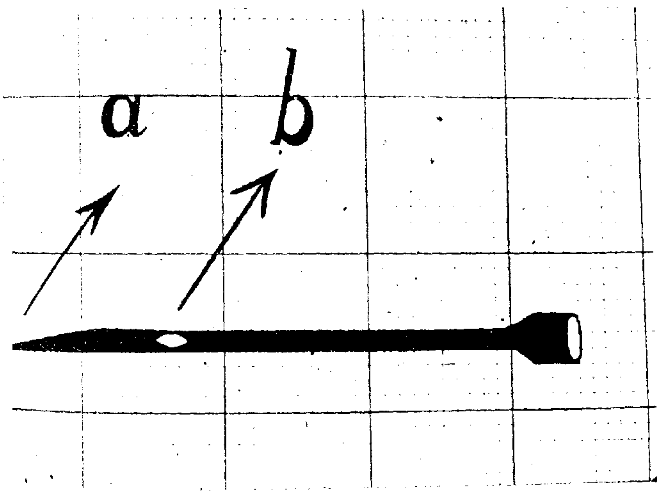
The value of a sugarcane seedling depends, from a commerc point of view, mostly on its sugar content; and to determine th it is essential that its juice should be examined. The usual metho of analysis do not, when a cane is young, tell us what it would after maturity. Moreover, these methods involve the destructi of the cane before the juice can be examined. It is well know that canes of the same age and belonging to the same clump va within very wide limits. Such being the case, the results of analys

i young cane cannot be compared with those of an old cane he same clump. To know what a young cane will be at the e of harvest, requires a preliminary knowledge of the life-history he cane as told by itself. It thus becomes necessary to test a e periodically during the various stages of its growth, and this lves itself into devising a method for extracting a small quantity uice from the cane sufficient for purposes of examination without reciably interfering with its growth.

II. Preliminary.

Method of extracting juice.

A number of methods for extracting the juice from the sugar-e were tried, and in the end the following method was found e most suitable. The sharp open end of an ordinary hypodermic dle (*a* in Fig. below) was plugged with melted tin and a small e was bored in the side of the needle at *b* as in the figure.



The needle when inserted in a slightly slanting position—this be easily carried out with a little practice—into the internode

of a sugarcane, ruptures the neighbouring cells during its passage and the juice from these cells passes into the needle by the side hole. By this means about two drops of juice can be obtained.

Injury to the cane likely to occur on account of puncturing.

The needle while passing through the cane, besides rupturing the neighbouring cells, also introduces fermentative organisms. To ascertain the extent of damage likely to occur on this account, a number of canes were punctured with a sterile needle at three or four places in each internode, and the holes thus made were immediately closed with soft paraffin. Another set of canes were punctured in the same way; only the needle was not sterilized and the holes were not closed with paraffin. At the end of one month all the canes were cut longitudinally and the state of affairs noted. It was found that the canes covered with paraffin were practically unaffected except for a thin reddish streak in the region of the path of the needle, while, in the case of those not covered with paraffin, the streaks were broad, and in a few cases signs of fermentation were also noticed. The canes were found to be otherwise normal in every case. It is thus clear that this method of extraction, with necessary precautions, by the modified form of hypodermic needle gives juice without affecting the cane to any appreciable extent. Additional proof of this will be found later in the course of this paper.

Method of examining the juice.

The quantity of juice obtained as above permits of only one method of examination, and that is the determination of the index of refraction of the sample of juice and the deduction therefrom of the percentage of total solids calculated as sucrose. An extraction gives sufficient juice to give a clear field with the Abbe refractometer, the instrument used throughout this work.

According to W. E. Cross,[1] who gives a resumé of the various opinions on the use of the refractometer, the work of Hugh Main

[1] Cross, W. E. *Louisiana Tech. Bulletin No.* 1[illegible].

ollman, and Smith and Stolle showed conclusively the absolute eliability of the refractometer for determining the percentage f sugar in solution. Much work has been done on the various spects of the use of refractometer, among which may be cited iechmann's refractometric studies,[1] Pellet's investigations,[2] and e experiments of Nowakowski and Muzyuski[3] who recommended e use of the Abbe instrument for juices, syrups, and molasses, as ving results which are better than those of the picnometric method, d which indeed approximate very closely to those of the drying ethod.

The scale of the Abbe instrument is graduated to three places decimals, the fourth place being estimated by the eye. A maxi-um error of 0·0001 in the refractive index corresponding to $\pm 0{\cdot}1$ r cent. of the dry substance may be obtained.

The method of extraction and examination of the juice was follows :—

The cane was punctured with the needle sterilized in an ordinary irit lamp flame and cooled, and the small quantity of the juice at passed into the needle was dropped on the lower half of the ism of the refractometer. The two halves of the prism were mediately closed and the scale reading and the temperature of servation recorded. The needle was then thoroughly washed, th inside and outside, with distilled water and dried ready for e next puncture. The puncture made in the cane was immediately osed with a small quantity of soft paraffin. The corrected percent-ges of total solids on the basis of sucrose were next calculated om the observed scale readings. It was found that, with a ttle care and experience, successive extractions of juice from single internode of a cane gave juice of practically the same fractive index. That the concentration of the juice in any art of the internode is the same, will be seen in a subsequent age.

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[1] Cross, W. E. *Louisiana Tech. Bulletin No. 135*
[2] *Ibid.*
[3] *Ibid.*

The refractive indices of sugars and other salts found in sugar-cane juices.

The juice of the sugarcane consists mostly of a mixture of sucrose, glucose and a small quantity of salts and other substances. It is important, therefore, to ascertain beforehand how these substances interfere with the refractometric readings. To obtain information on these points, the refractive indices of solutions of pure sucrose and glucose at different concentrations were determined. Pure sucrose (99·9 per cent.) and pure dextrose (99·6 per cent.) were taken, and solutions of these, varying from 1–10 per cent., were examined in the refractometer.

TABLE I.

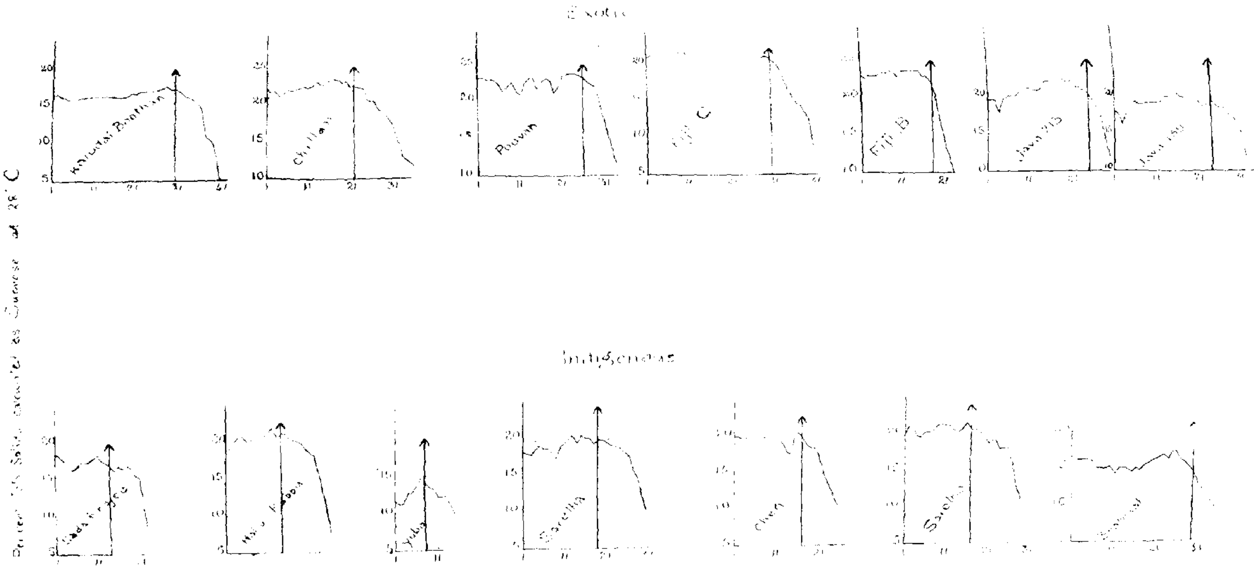
Showing the refractive indices of sucrose and glucose solutions at various concentrations.

Strength of solution %	Temperature of observation °C.	Sucrose		Dextrose	
		n_D	Solids at at 28°C. %	n_D	Solids at at 28°C. %
1	28	1·3337	1·10	1·3335	1·00
2	28	1·3350	2·05	1·3350	2·05
3	28	1·3365	3·05	1·3365	3·05
4	28	1·3380	4·05	1·3381	4·10
5	28	1·3396	5·10	1·3395	5·05
6	28	1·3410	6·05	1·3408	5·90
7	28	1·3425	7·05	1·3424	7·00
8	28	1·3440	8·05	1·3440	8·05
9	28	1·3455	9·05	1·3456	9·10
10	28	1·3471	10·10	1·3470	10·05

These results are in accordance with those of Stolle[1] and Tolman and Smith[2] who showed that, at all concentrations, glucose and sucrose in solution have the same refractive index. The latter authors have further shown that sucrose, fructose and glucose all have the same indices of refraction in solutions of concentration

[1] Stolle. *Zeit. Ver. Zuckerind.* 1901; from *Louisiana Bull. No.* 1[illegible].
[2] *Journ. Amer. Chem. Soc.*, Oct., 1906.

CHART I.



Internodes from bottom to top of cane up to the very tender portion.

N.B. Arrow indicates position of highest dead-leaf.

90 per cent. Subsequently Prinsen Geerligs[1], working with e Abbe instrument, first confirmed the observations of Tollman d Smith[2] regarding the specific refraction of sugars, and then tained data on such salts as chlorides, sulphates, acetates, etc., are commonly found in the sugarcane products. He showed at calcium salts had a higher, and the potassium salts a lower, index refraction than sucrose, and proved by experiment that a mixture these salts, such as is usually found in sugar products, gave results ry nearly the same as those of pure sucrose. The amount of lts to be met with in cane juices is very small, and any slight ıctuation in the total solids calculated as sugar is, therefore, gligible.

III. Experimental.

Having worked through the initial difficulties, the next step the course of the investigation was how best to apply the above ethods to a growing sugarcane to determine its sucrose-yielding ficiency. The object aimed at was to fix the status of a seedling examining the juice of a single internode in that particular cane. ıe main difficulty was how to locate the internode which would rve as an index for the whole cane within the limits of experimental ror.

Venkataraman and Krishnamurti Row[3] made sectional analyses sugarcanes and have shown that the highest sucrose content hich they call sucrose index of the cane) is found in the young ne in the lowest section, but as the cane advances in maturity, ıe region of the highest sucrose content gradually moves upwards. hey based their conclusions on analyses made of different canes elonging to the same clump, after dividing these into 5 or 6 parts om the bottom. Their results, therefore, refer to portions of cane ut not to particular internodes, and consequently cannot be of help ı determining the particular internode or internodes which would erve as an index to a cane. Besides, their results refer to sucrose s determined by the polariscope, while the results in this paper

[1] Cross, W. E. *Louisiana Techn. Bull. No.* 135.
[2] Loc. cit.
[3] *Agric. Journ. India*, Spl. Indian Science Congress Number, 1917.

refer to the total sugars. A number of sugarcanes, kindly supplied by the Government Cane-breeding Station, were examined joint by joint from bottom to top, noting the places of highest dead leaf, lowest living leaf, and other botanical peculiarities, with a view to ascertaining how the total sugars are distributed in the cane. The results of 14 canes thus examined are tabulated in Table II (p. 45_) and plotted in Chart I. The canes examined consisted of both exotic and indigenous varieties.

One striking point of difference between the indigenous and exotic canes is that the fall in the percentage of total solids is very steep or sudden in the case of the exotic canes, while it is more gradual in the case of the indigenous ones, thus showing a marked difference between the two varieties.

It will be seen that in many cases the joint at or very near the highest dead leaf contained the maximum amount of sugars, while in the case of some it was removed as far below as 5 or 6 joints towards the base. In no case was it above the highest dead leaf joint from the bottom. The botanical notes show that the canes were almost ripe at the time of sampling.

W. C. Stubbs[1] says, "each joint has its leaf and through the latter the food of the former is assimilated, and it is believed when the joint casts its leaf, the process of assimilation ; so far as that joint is concerned, is completed—it is mature." If this be the case one would expect a flat curve, *i.e.*, uniform sugar content from the bottom of the cane up to the highest dead leaf joint, or if any deterioration is taking place in the lower joints an inclined curve with its maximum about the highest dead leaf joint and exhibiting a gradual fall above the dead leaf joint. The curves in Chart I do not seem to endorse this view. The maximum sugar content is not at the highest dead leaf joint in all cases, nor is it located at any definite distance from the highest dead leaf joint except that it is never above this point.

It is possible that the canes examined were of different degrees of ripeness and consequently the internode containing the maximum

[1] Stubbs. *Sugarcane*, vol. I, page 14.

igar content is removed more or less from the highest dead leaf. i order to test this point a number of seedling canes of about nine onths old, both exotic and indigenous, were examined, from the ternode just above the ground level to that carrying the highest ead leaf, at intervals of one month. The results obtained e tabulated in Table III (p. 467) and graphically described in hart II.

It will be seen that when the cane is young the point of maximum igar content is in the basal sections, but as the cane matures, this adually moves up the cane towards the highest dead leaf joint. hese results are in complete accord with those of Venkataraman id Krishnamurti Row[1] whose work started simultaneously with ie author's but was quite independent and was carried out by iethods of experiment entirely different from those employed by ie author. The results suggest that in a young cane the sugar ontent of the internode nearer to the ground gives roughly an idea f the capacity of the seedling.

With this information, a number of B. 208 seedlings were xamined in 1916 when they were about nine months old, and the sults were compared with those obtained by crushing the same anes after maturity, as well as with the bulk harvest results of the ame clump. A similar set of experiments were made in the year 917. In both cases the results obtained are not entirely satis- actory; nevertheless, they are encouraging in that nearly 0 per cent. of the results corresponded with the preliminary tests hough the rest failed to keep up to the original indications. The ause of this difference is being investigated, and this portion of the vork will be carried on as opportunity occurs.

Subsidiary results.

An examination of the curves in Chart II shows that :—

1. When the cane is *young*, the joint with the highest dead eaf contains the lowest amount of sugar of all the dead leaf joints, out its sugar content gradually increases, however, as the cane

[1] Loc. cit.

matures, thus indicating that further storage of sugar takes place after the leaf is dead.

2. As the cane grows there is a general levelling about the middle of the curves indicating either the possibility of the sugar moving upwards from internode to internode or its being used up in the lower joints in the building up of cane tissue.

3. A large increase in the amount of total sugars occurs in the internode even after the leaf is dead and cast.

There are thus strong indications in favour of formation of sugars in the internode after its leaf is cast, and it was thought desirable to obtain further proof in support of this view. Barnes[1] has shown that when cut, after-ripeness actually occurs in sugarcane under proper conditions. His results, though not conclusive, were based on experiments made with different canes, and this fact minimises the importance of the conclusions drawn. An attempt was, therefore, made to experiment with one and the same internode of a sugarcane by cutting this into two halves and watching if any increase in sugars occurred in one of the halves when kept for some time. As a preliminary to this, experiments were made to ascertain if the concentration of the juice is the same throughout an internode.

Two samples were taken from an internode by means of a cork-borer and the sugars from these were extracted by means of 80 per cent. alcohol and examined.

TABLE IV.

Showing the sugar content of two portions of an internode.

No. of experiment	Bottom		Top	
	Sucrose	Glucose	Sucrose	Glucose
1 ..	1·34	Trace	1·34	Trace
2 ..	1·38	"	1·38	"
3	1·26	"	1·25	"
4 ..	1·89	"	1·88	"

[1] Barnes, J. H. *Agric, Journ. India*, April, 1917.

Having ascertained that the concentration of the juice of an iternode is uniform, the following series of experiments were made. The canes after being brought to the laboratory were stripped their leaves, and two internode lengths about the dead leaf joint ere cut off with a sterile knife. The cut portions were next cut to two halves longitudinally, so that each half had one bud and oot zone intact. One of the two longitudinal halves was incubated a cool place for about 48 hours. The other half was quickly ropped into boiling alcohol (containing 1 part ammonia in 100 arts of alcohol) so as to bring to a sudden stop all vital activity the cane. This was next removed from the alcohol, dried and duced to a powder. The sugars were afterwards extracted with lcohol (80 per cent.), the solvent distilled off, and the residual sugars xamined according to the methods of Davis[1], and of Davis, Daish nd John.[2] At the end of 48 hours the other halves were also ubmitted to the same treatment and analysed (Table V).

TABLE V.

Showing the effect of storage on portions of internodes of sugarcanes preserved for 48 hours in a cool place.

me of cano	TOTAL SOLIDS ON DRY MATTER %			SUCROSE ON DRY MATTER %			GLUCOSE ON DRY MATTER %		
	Initial	Final	+ or −	Initial	Final	+ or −	Initial	Final	+ or −
i Sports of iped Mauri-s ..	66·50	61·40	− 5·10	49·57	43·30	− 6·27	11·43	10·90	− 0·53
Ditto ..	64·15	69·71	+ 5·56	49·69	57·82	+ 8·13	2·56	2·55	− 0·01
ed Mauritius	58·70	62·80	+ 4·10	40·60	45·71	+ 5·11	8·29	9·17	+ 0·88
Ditto ..	49·80	54·90	+ 5·10	38·70	46·00	+ 7·30	11·25	10·50	− 0·75
Ditto ..	60·20	63·10	+ 2·90	48·10	50·00	+ 1·90	7·26	7·30	+ 0·04
Ditto ..	38·10	46·40	+ 8·30	28·70	33·40	+ 4·70	12·16	12·00	− 0·16
Ditto ..	52·40	53·80	+ 1·40	45·80	46·50	+ 0·70	6·29	8·00	+ 1·71
Ditto ..	60·30	65·80	+ 5·50	48·60	54·40	+ 5·80	4·51	4·40	− 0·11
dai Boothan	57·60	65·40	+ 7·60	48·40	56·30	+ 7·90	Traces	Traces	
Ditto ..	62·40	52·80	− 9·60	51·50	41·70	− 9·80	Do.	Do.	
Ditto ..	50·30	50·03	− 0·27	36·10	35·13	− 0·97	3·31	4·75	+ 1·44
Ditto ..	56·90	54·30	− 2·60	30·62	35·90	+ 5·30	6·00	11·00	+ 5·00

[1] Davis. *Journ. Agric. Science*, 1916.
[2] Davis, Daish and John. *Journ. Agric. Science*, 1913, 1914 and 1915.

Out of the twelve experiments made, there was a distinct increase of sugars and total solids in eight, while the other four experiments showed loss of sugars and total solids. These results are not, of course, conclusive, but they certainly indicate extra formation of sugars. It is possible that the loss of sugar and total solids on four occasions may have been due to bacterial fermentation, though every effort was made to ensure sterility. Since submitting this paper to the Chairman of the Agricultural Section of the Indian Science Congress the Annual Report of the Agricultural Research Institute, Pusa was published, wherein Dr. Harrison records an increase of both total solids and sugar in two varieties of canes under windrowed conditions.

Discussion of the results.

Before proceeding to discuss the results it is well to see how far the methods of experiment employed affected the canes examined. The shape of the curves cannot be attributed to any changes resulting from puncturing the canes, because if that were the case the lower portions of the curves could not have been steady as they are seen to be in almost all the cases.

The probable error due to the refractometer has been dealt with when dealing with that instrument. The error due to the methods of extracting the juice from the cane cannot be exactly estimated, but the extractions were all made under conditions as uniform as possible, and any error is believed to be constant or nearly so. As for temperature the necessary corrections were applied to all the readings. The total solids calculated from the refractive indices were all taken to represent sugar, as the amount of substances other than sucrose and reducing sugars is so small that they may be neglected. Besides, it has already been shown that sucrose, glucose and other salts usually found in sugarcane juice have the same refractive index.

It is not claimed that the results so far obtained are in any way complete, but there can be no doubt as to the general indications, particularly in view of the fact that they are in general agreement

th those of Venkataraman and Krishnamurti Row[1] who drew eir conclusions from entirely different methods.

A consideration of the foregoing results brings us at once to e question, "how does the cane make its sugar." A large volume literature exists on the formation of sugar in the beet, but the mount of work done on the formation of sugar in the sugarcane, udging from the literature at the author's disposal, is meagre and ontroversial.

Aimne Girard[2] in 1884, from comparative investigations of he amounts of cane sugar and grape sugar present in different arts of the sugarcane in the afternoon and before sunrise, concluded hat the formation of sucrose from glucose takes place entirely in he leaves under the influence of sunlight and that the sucrose hereupon ascends the cane through the petioles, etc., and collects here.

Winter[3] (1888) from an examination of the sugars of a normal ipe sugarcane says that the assumption that sucrose is formed rom glucose and levulose can no longer be allowed.

Beeson[4] (1895) regards glucose as the first assimilation product.

Prinsen Geerligs[5] (1896) concludes from data furnished by stimations of the optical and reducing powers before and after nversion, that the ratio between sucrose, dextrose and levu- se in the leaves from the unripe sugarcane is 1 : 2 : 4. In the pper portion of unripe canes of six months' growth the ratio was :1:1, three months later it became 3 : 2 : 1, whilst in the lower joints f canes nine months old the ratio found was 82·5 : 3 : 1. He thus aintains that sucrose is built up from reducing sugars.

Went[6] (1898) made a thorough study of this question and con- luded from a microchemical examination of the sugarcane that

[1] Loc. cit.

[2] Aimne Girard. *Compt. Rend.*, XCVII, 1305; abstract *Journ. Soc. Chem. Industry*, 1884.

[3] Winter. *Zeit. f. Zuckerind*, 1880, 780; abstract *J. S. C. I.*. 1888, p. 761.

[4] Beeson. *Bull. Assoc. Chem.*, 1895, XIII, 362; abstract *J. S. C. I.*, 1895.

[5] Prinsen Geerligs. *Chem. Zeit.*, 1896, XX, 721; abstract *J. S. C. I.*, 1896.

[6] Went, P. A. F. C. *Bull. de l'Assoc. des Chemi. de Sucr. et de Dist.*, 1898, 15(12), pp. 217-1226; abstract *J. S. C. I.* and *Cane Sugar* by Noel Deerr.

glucose, sucrose, starch and tannin are found in the parenchymatous cells and not in the vascular bundles while the contrary is the case with the albuminoids. According to this investigator the following phases are distinguished in the life-history of the stalk :

(1) In very young parts of the stalk, only starch and albumen are present, which are consumed little by little in the formation of cellulose.

(2) In young, rapidly growing parts of the stalk, the cane sugar brought down by the leaf is inverted, and whereas in the leaf the proportions of sucrose, dextrose and levulose were as 4 : 2 : 1, in the young joints the proportions are 0·8 : 1 : 1. A part of the invert sugar is used up in the formation of fibre, a part unites with the amides to form albumen, and a part is deposited as starch. In consequence of the inversion, the osmotic pressure is raised and this tends to favour the absorption of plant food.

(3) In older joints the sucrose formed in the leaf remains unchanged when it reaches the joint and the reducing sugars are used up, partly in respiration, or perhaps partly converted by a synthetic enzyme action into sucrose ; of the reducing sugars that remain, the dextrose is generally in excess.

(4) When the stalks are developed, the accumulated invert sugar is converted into sucrose ; of the invert sugar remaining, the dextrose is generally in excess.

(5) When the stalks are ripe the leaves die and the accumulation of sugar gradually ceases ; the remainder of the invert sugar is changed to sucrose, eventually only traces of invert sugar remaining.

(6) When the stalks are overripe the sucrose is reconverted into invert sugar, but this change does not prevent the younger parts of the cane accumulating sugar. It will be noticed that Went's figures for the ratio between sucrose and reducing sugars in the leaf are entirely different from those formed by Geerligs.

Pellet[1] (1914) maintains that the results obtained by him point to conversion of the reducing sugars into sucrose after reaching the cane stalk. Colin[2] (1914) takes a similar view.

Other investigators on beet-root and foliage leaves are divided, as in the case of the sugarcane investigators, some holding sucrose and some glucose as the product directly formed in and translocated by the leaf.

The most recent investigators in this field are Davis and Colin. Davis[3] (1915-1916) after a very careful examination of the carbohydrates of the leaves of the mangold concludes that the sugar is translocated by the leaf as hexoses which are subsequently transformed into sucrose.

Colin[4] (1916-1917) has stated that sucrose contained in the beet-root is reproduced by a small number of cells from the reducing sugars and that normally invertase is not present in the root. The same investigator in a later communication[5] criticises the two theories advanced, in the light of the latest researches, and concludes that sufficient evidence has not yet been obtained to establish the proposition that sucrose cannot pass unchanged from the leaf to the root. Moreover, he admits that there exists considerable evidence pointing to the polymerisation of reducing sugars into sucrose in the beet-root.

The bulk of evidence seems to favour the view that sucrose in the sucrose-storing plants is built up either in the root or in the stem from the reducing sugars sent into it by the leaf. Analyses of top and bottom halves of sugarcane made in this laboratory (Table VI) show that the top halves contain more glucose than the bottom halves and this is apparently in general accord with the views just quoted above.

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[1] Pellet. Private communication to Mr. W. A. Davis quoted in *Journ. Agric. Science*, vol. VII, 1915-1916.

[2] *Journ. Agric. Science*, vol. VII, 1915-1916.

[3] Davis. Loc. cit.

[4] Colin. *Rev. Gen. Botan.*, XXVIII, 289-99, 321-8, 368-80 (1916), XXIX, 21-32, 56-64, 89-96, 113-27 (1917), from *Chem. Abstracts*, vol. XII, 1918.

[5] *Bull. Chem. Sucr. Dist*, 35 (171-178), 1917, from *Chemical Abstracts*, vol. XIII (1918).

TABLE VI.

Showing analyses of top and bottom halves of sugarcane.

Name of cane	Bottom half			Top half		
	Surcose	Glucose	Ratio glucose / sucrose	Sucrose	Glucose	Ratio glucose / sucrose
	%	%		%	%	
B. 147	14·11	1·31	0·09	13·35	1·61	0·11
Fiji B.	18·02	0·70	0·04	14·66	1·43	0·0[illegible]
B. 1529	18·68	0·27	0·01	17·92	0·40	0·0[illegible]
B. 3412	14·82	1·25	0·08	12·91	1·35	0·1[illegible]
J. 247	14·04	1·04	0·07	13·18	1·39	0·11
B. 6450	16·37	0·40	0·02	15·09	1·04	0·0[illegible]
Tana Blanche ..	15·55	0·78	0·05	13·56	0·88	0·0[illegible]
Ashy Mauritius ..	19·04	0·21	0·01	17·44	0·39	0·0[illegible]
Red Mauritius sports ..	14·69	1·67	0·11	14·05	1·78	0·1[illegible]
B. 208	18·95	0·42	0·02	18·19	0·60	0·0[illegible]
Fiji C.	15·69	0·63	0·04	13·95	0·83	0·0[illegible]

From a study of the previous literature we learn that all a[illegible] agreed that *sugar* in one form or other is sent to the cane by the lea[illegible] and nothing is said of the fate of the sugar when once it ente[illegible] the stalk. It is only an assumption, without direct experiment[illegible] evidence, that sucrose is the result of polymerisation of the reducin[illegible] sugars. It has been shown that sucrose and reducing sugars ha[illegible] the same refractive index, and if nothing more than conversion [illegible] reducing sugars into sucrose takes place after the leaf is cast, the[illegible] is no need for any increase in the total solids as shown by the refrac[illegible] tometer. The results of experiments detailed in this paper distinctl[illegible] show that there is an increase in total solids with production of suga[illegible] in large quantities in an internode after the death of the leaf attache[illegible] to it. How is this extra sugar formed ?

The explanation that readily suggests itself from a study of th[illegible] curves in Chart II is that, as the cane grows, the internodes a[illegible] gradually filled up by the sugar sent in by the living leaves above[illegible] If this is so, the amount of work falling on the green leaves produce[illegible] during the later stages of the growth of the cane, is greater tha[illegible] that carried out by the earlier leaves, and this appears to be to[illegible] much for the new ones. It cannot be argued that increased outpu[illegible]

possible on account of increase in leaf area. In sugarcane each internode has only one leaf and old leaves die off as new ones come up. In India it takes about twelve months from the time of planting for a cane crop to mature, and as the canes were examined when they were about eight months old and thus at a sufficiently adult stage at the time of examination, there could not have been any considerable difference between the total leaf area at the beginning and closing stages of the experiment.

The green leaves have their own urgent work to do. They have to provide large quantities of sugar for the building up of their internodes and proteids, besides sending down material to older joints for purposes of storage. This would appear to be an undue strain on the existing green leaves, and it does not seem reasonable to suppose that when the demands from the growing parts are urgent the leaves would make an attempt at supplying the lower joints which could not be provided for by their own leaves with sugar.

Another possible explanation is that the sugars as soon as they are sent in by the leaf into the stem are converted into carbohydrates of higher molecular weight of the types of hemicelluloses, starch and such others for purposes of building up cane tissue. These after the death of the leaf are slowly reconverted into simple sugars. The formation of cellulose-like substance from sucrose in beet juice by a ferment resembling diastase was observed by E. Durin.[1] Brown and Morris[2] as a result of their investigations on tropeolum leaves hold the view that cane sugar is the precursor of cellulose. This view is also supported by Cross and Bevan.[3] Dr. Maxwell[4] in 1893-1894 found in the sugarcane bodies resembling gums which on hydrolysis yielded glucose. He was then not able to explain the physiological significance of the presence of these bodies in sugarcane.

Small quantities of starch as a sheath round the vascular bundles and diastase were recognized by the author in the younger joints of

[1] Durin. *Compt. Rend.*, LXXXII, 1078; LXXXIII, 128.
[2] Brown and Morris. *J. C. S.*, 1890, LVII. 458.
[3] Cross and Bevan. *Cellulose.*
[4] Maxwell. *Louisiana Bull. No. 38.*

the cane while none could be found in the older joints. It is possible that the diastase is functioning both as disintegrator and builder of complex carbohydrates. It is also possible in view of the evidence adduced that the function of the leaf is a physiological one; growth continues as long as the leaf is alive, and during this time the tendency of the internode is to build up higher polysaccharides for its own benefit from the sugar sent in by the leaf till the connection with the leaf is cut off, and that after the death of the leaf re-elaboration of the material takes place as observed by Stubbs.[1]

Thus, with our present knowledge of the physiology of sugarcane, two methods of explanation seem possible. Which of the two is more tenable has to be shown by further investigation. The bulk of the evidence adduced seems to favour the second view.

IV. SUMMARY AND CONCLUSIONS.

The results so far obtained may be summarized thus:—

(1) A method of extracting and examining small quantities of juice from sugarcane, without harming the cane to any appreciable extent, was devised.

(2) By the application of the above method the total sugar content of each joint of sugarcane was determined during the various stages of its growth, thus obtaining a glimpse into the life-history of the cane, as told by itself.

(3) In a young cane the maximum amount of total sugars is found at the basal joints; as the cane grows older and older, this maximum sugar content moves higher and higher till it is at the highest dead leaf joint. The nearer the maximum total sugar content is to the highest dead leaf joint, the more advanced it is in maturity.

(4) A large increase of sugars occurs in the internode of the cane after the death of its attendant leaf; this increa

[1] Loc. cit.

may be due either to the influx of sugars from the growing parts above or to further elaboration of the material already sent in by the leaf before its death. What it exactly is, is to be decided by further investigation.

(5) The formation of sucrose in the cane does not seem to be due to such a simple process as the direct polymerisation in the stem of reducing sugars translocated by the leaf, as is generally supposed to be the case.

In conclusion, I have to express my deep sense of gratitude to C. A. Barber, C.I.E., Government Sugarcane Expert, for freely rding facilities for work at the Government Cane-breeding Station, mbatore, to Dr. W. H. Harrison for suggesting this investigation, l to Dr. R. V. Norris for criticism of the results and advice before paper was finally written up.

I am also indebted to my colleagues Messrs. T. S. Venkataraman, Krishnamurti Row and U. Vittal Rao, Assistants to the vernment Sugarcane Expert, for their kind help and friendly icism of the results during the period of my work at the Caneeding Station.

Table II.

Showing the total sugar content of each internode of maturing sugarcanes as shown by the refractometer.

No. of internode from base	Observed n D	Observed temp. °C	Total solids calculated as sugar at 28°C. %	Remarks
		Kaludai Boothan		
1	1·3595	27·0	17·98	Cane maturing.
2	1·3595	27·2	17·99	
3	1·3590	27·5	17·71	
4	1·3580	27·5	17·06	
5	1·3575	27·3	16·74	
6	1·3575	27·3	16·74	
7	1·3576	27·3	16·79	
8	1·3578	27·4	16·96	
9	1·3583	27·0	17·23	
10	1·3584	27·0	17·33	
11	1·3585	27·1	17·38	
12	1·3587	27·2	17·54	
13	1·3585	27·5	17·41	
14	1·3586	27·5	17·46	
15	1·3586	27·6	17·45	
16	1·3578	27·6	16·95	
17	1·3578	27·6	16·95	
18	1·3580	27·6	17·05	
19	1·3590	27·6	17·70	
20	1·3595	27·6	18·00	
21	1·3595	27·5	18·01	
22	1·3600	27·4	18·31	
23	1·3600	27·4	18·31	
24	1·3605	27·4	18·61	
25	1·3605	27·4	18·61	
26	1·3610	27·4	18·91	
27	1·3615	27·5	19·21	
28	1·3626	28·0	19·90	
29	1·3612	28·0	19·05	
30	1·3610	28·4	18·98	Base carried highest dead leaf.
31	1·3601	28·6	18·44	Half dead leaves.
32	1·3585	28·8	17·51	
33	1·3575	29·0	16·87	
34	1·3565	29·0	16·27	
35	1·3550	29·0	15·32	
36	1·3530	29·0	14·07	
37	1·3495	29·0	11·77	Base carried lowest fully green leaf.
38	1·3474	29·0	10·37	
39	1·3445	29·1	8·47	
40	1·3395	29·2	5·12	
41	1·3395	29·2	5·12	
42	1·3395	27·3	4·99	

TABLE II.—(*Contd.*)

No. of internode from base	Observed n D	Observed temp. °C	Total solids calculated as sugar as 28° C. %	REMARKS
		SADA KHAJEE.		
1	1·3605	27·0	18·58	A healthy cane with a full green tuft. Tuft not closing.
2	1·3097	27·0	18·08	
3	1·3590	27·2	17·69	Buds lightly swelling.
4	1·3578	27·5	16·96	
5	1·3565	27·5	16·16	
6	1·3570	27·6	16·47	On cutting showed borer attack.
7	1·3584	27·6	17·37	
8	1·3585	27·6	17·42	
9	1·3585	27·8	17·44	
10	1·3590	28·0	17·75	
11	1·3600	28·0	18·35	
12	1·3585	28·0	17·45	
13	1·3584	28·0	17·40	
14	1·3575	28·0	16·80	Highest dead leaf.
15	1·3567	28·0	16·30	Do. half dead leaf.
16	1·3575	28·0	16·80	
17	1·3570	28·0	16·50	Fully green leaves.
18	1·3575	28·0	16·80	
19	1·3570	28·0	16·50	
20	1·3555	28·2	15·59	
21	1·3550	28·2	15·24	
22	1·3480	28·2	10·69	
23	1·3430	28·2	7·39	
		CHITTAN.		
1	1·3665	28·0	22·20	Cane maturing.
2	1·3652	28·4	21·47	
3	1·3655	28·4	21·68	
4	1·3645	28·5	21·09	
5	1·3650	28·5	21·39	
6	1·3655	28·5	21·69	
7	1·3655	28·5	21·69	
8	1·3657	28·6	21·85	
9	1·3660	28·6	22·00	
10	1·3665	28·6	22·25	
11	1·3660	28·7	22·00	
12	1·3665	28·8	22·26	
13	1·3673	28·6	22·75	
14	1·3670	28·5	22·54	
15	1·3670	28·5	22·54	
16	1·3675	28·4	22·88	
17	1·3680	28·5	23·14	
18	1·3680	28·5	23·14	
19	1·3670	28·2	22·51	
20	1·3675	28·2	22·86	
21	1·3662	28·3	22·07	
22	1·3663	28·4	22·12	Highest dead leaf.
23	1·3660	28·3	21·97	
24	1·3655	28·3	21·67	

TABLE II.—(*Contd.*)

No. of internode from base	Observed n D	Observed temp. °C.	Total solids calculated as sugar at 28°C. %	REMARKS
		CHITTAN.—*Concld.*		
25	1·3636	28·0	20·50	
26	1·3630	28·0	20·15	
27	1·3630	28·0	20·15	
28	1·3609	28·0	18·90	
29	1·3605	28·0	18·65	
30	1·3575	28·0	16·80	
31	1·3549	28·0	15·20	
32	1·3515	28·0	12·90	
33	1·3505	28·0	12·30	
34	1·3490	28·0	11·40	
		POOVAN.		
1	1·3678	28·0	23·00	Cane maturing.
2	1·3678	28·0	23·00	
3	1·3673	28·0	22·70	
4	1·3675	28·2	22·86	
5	1·3673	28·2	22·71	
6	1·3660	28·4	21·97	
7	1·3647	28·5	21·17	
8	1·3670	28·5	22·52	
9	1·3645	28·6	21·08	
10	1·3640	28·6	20·83	
11	1·3665	28·7	22·23	
12	1·3675	28·7	22·88	
13	1·3675	28·7	22·88	
14	1·3650	28·6	21·38	
15	1·3670	28·7	22·53	
16	1·3672	28·8	22·69	
17	1·3670	28·6	22·53	
18	1·3640	28·6	20·83	
19	1·3655	28·6	21·68	
20	1·3675	28·6	22·88	
21	1·3683	28·5	23·32	
22	1·3685	28·7	23·43	
23	1·3687	28·7	23·53	
24	1·3686	28·7	23·48	
25	1·3685	28·6	23·43	
26	1·3675	28·6	22·88	Highest dead leaf.
27	1·3665	28·6	22·23	
28	1·3660	28·6	21·98	
29	1·3655	28·7	21·68	
30	1·3610	28·7	18·98	
31	1·3568	28·6	16·43	
32	1·3540	28·7	14·68	
33	1·3495	28·6	11·73	Fully green leaf.
34			No juice	
35			No juice	

TABLE II.—(*Contd.*)

No. of internode from base	Observed n_D	Observed temp. °C	Total solids calculated as sugar at 28°C. %	REMARKS
			FIJI C.	
1	1·3640	27·0	20·73	
2	1·3645	27·0	20·98	Cane nearing maturity.
3	1·3653	27·0	21·43	
4	1·3658	27·1	21·78	
5	1·3658	27·2	21·79	
6	1·3662	27·5	22·01	
7	1·3663	27·5	22·06	
8	1·3660	27·5	21·91	
9	1·3650	27·6	21·31	
10	1·3655	27·6	21·61	
11	1·3645	27·8	21·03	
12	1·3645	27·8	21·03	
13	1·3640	27·8	20·78	
14	1·3645	27·8	21·03	
15	1·3645	27·8	21·03	
16	1·3645	27·8	21·03	
17	1·3640	27·8	20·78	
18	1·3645	27·8	21·03	
19	1·3647	28·0	21·15	
20	1·3650	28·0	21·35	
21	1·3650	28·0	21·35	
22	1·3652	28·0	21·45	
23	1·3652	28·0	21·45	
24	1·3645	28·0	21·05	
25	1·3640	28·0	20·80	
26	1·3637	28·0	20·60	
27	1·3638	28·0	20·65	
28	1·3635	28·0	20·45	
29	1·3625	28·0	19·85	
30	1·3615	28·0	19·25	Highest dead leaf.
31	1·3590	28·0	17·75	
32	1·3565	28·0	16·20	
33	1·3550	28·0	15·25	
34	1·3535	28·0	14·30	
35	1·3530	28·0	14·00	Lowest fully green leaf.
36	1·3515	28·0	12·90	
37	1·3500	28·0	12·00	
38	1·3445	28·0	8·40	
			HALLU KABBU.	
1	1·3602	30·0	18·59	
2	1·3610	30·0	19·09	Cane immature
3	1·3618	30·0	19·59	
4	1·3635	30·0	20·59	
5	1·3635	30·0	20·59	
6	1·3625	30·0	19·99	
7	1·3630	30·0	20·29	
8	1·3635	30·0	20·59	
9	1·3640	30·1	20·94	
10	1·3635	30·2	20·60	
11	1·3645	30·3	21·21	
12	1·3653	30·5	21·68	

TABLE II.—(*Contd.*)

No. of internode from base	Observed n D	Observed temp. °C.	Total solids calculated as sugar at 28°C. %	REMARKS
		HALLU KABBU.—*Concld.*		
13	1·3633	30·5	20·53	
14	1·3640	30·5	20·98	Highest dead leaf.
15	1·3640	30·5	20·98	
16	1·3630	30·5	20·33	
17	1·3628	30·5	20·23	
18	1·3625	30·5	20·03	
19	1·3620	30·5	19·78	
20	1·3605	30·5	18·83	
21	1·3597	30·5	18·33	
22	1·3590	30·5	17·92	Lowest fully green leaf.
23	1·3555	30·5	15·77	
24	1·3520	30·5	13·47	
25	1·3470	30·5	10·22	
26	1·3430	30·5	7·56	
		FIJI B.		
1	1·3675	29·5	22·95	
2	1·3670	29·5	22·60	
3	1·3675	29·8	22·97	Cane appears immature.
4	1·3673	29·8	22·82	
5	1·3673	29·8	22·82	
6	1·3682	29·8	23·32	
7	1·3680	29·8	23·22	
8	1·3683	29·8	23·42	
9	1·3682	29·8	23·32	
10	1·3670	29·8	22·62	
11	1·3675	30·0	22·99	
12	1·3675	30·0	22·99	
13	1·3675	30·0	22·99	
14	1·3677	30·0	23·09	
15	1·3677	30·0	23·09	
16	1·3670	30·0	22·64	
17	1·3660	30·0	22·69	
18	1·3655	30·0	21·79	Highest dead leaf.
19	1·3625	30·0	19·99	
20	1·3565	30·0	16·34	
21	1·3520	30·0	13·44	Lowest fully green leaf.
22	1·3495	30·0	11·84	
23	1·3460	30·0	9·54	
		J. 213.		
1	1·3615	30·0	19·39	
2	1·3615	30·0	19·39	Cane immature.
3	1·3615	30·0	19·39	
4	1·3585	30·0	17·59	Deep crack.
5	1·3615	30·0	19·39	
6	1·3625	30·0	19·99	
7	1·3625	30·0	19·99	
8	1·3624	30·0	19·94	
9	1·3635	30·2	20·60	
10	1·3639	30·2	20·85	
11	1·3640	30·4	20·97	
12	1·3635	30·3	20·61	

TABLE II.—(*Contd.*)

No. of internode from base	Observed n_D	Observed temp. °C.	Total solids calculated as sugar at 28°C. %	REMARKS
		J. 213.—Concld.		
13	1·3635	30·3	20·61	
14	1·3640	30·3	20·96	
15	1·3655	30·4	21·82	
16	1·3655	30·4	21·82	
17	1·3658	30·5	22·03	
18	1·3655	30·5	21·83	
19	1·3660	30·5	22·13	
20	1·3655	30·5	21·83	
21	1·3656	30·5	21·88	
22	1·3645	30·5	21·23	
23	1·3645	30·5	21·23	
24	1·3635	30·5	20·63	
25	1·3630	30·5	20·33	Highest dead leaf.
26	1·3615	30·5	19·43	
27	1·3600	30·5	18·53	
28	1·3575	30·5	16·98	
29	1·3530	30·6	14·19	Lowest fully living leaf
30	1·3495	30·6	11·89	
		J. 139.		
1	1·3595	26·2	17·92	
2	1·3590	26·5	17·65	Cane maturing.
3	1·3565	26·5	16·10	
4	1·3590	26·5	17·65	
5	1·3603	26·8	18·27	
6	1·3615	27·0	19·18	
7	1·3608	27·0	18·78	
8	1·3608	27·0	18·78	
9	1·3610	27·0	18·88	
10	1·3615	27·0	18·88	
11	1·3615	27·0	18·88	
12	1·3615	27·1	18·88	
13	1·3624	27·1	19·73	
14	1·3624	27·2	19·74	
15	1·3625	27·2	19·79	
16	1·3630	27·3	20·09	
17	1·3615	27·4	19·20	
18	1·3615	27·5	19·21	
19	1·3615	27·5	19·21	
20	1·3610	27·6	18·94	
21	1·3600	27·6	18·31	Half dead leaf.
22	1·3605	27·6	18·61	
23	1·3615	27·7	19·22	
24	1·3605	27·8	18·63	Highest dead leaf.
25	1·3598	27·8	18·18	
26	1·3598	27·8	18·18	
27	1·3585	27·8	17·43	
28	1·3575	27·8	16·78	
29	1·3564	27·8	16·08	
30	1·3545	28·0	14·95	Lowest fully green leaf.
31	1·3545	28·0	14·95	
32	1·3505	28·0	12·30	
33	1·3485	28·0	11·05	

TABLE II.—(*Contd.*)

No. of internode from base	Observed n_D	Observed temp. °C.	Total solids calculated as sugar at 28°C. %	REMARKS
			YUBA.	
1	1·3497	28·6	11·84	
2	1·3488	28·8	11·31	Late cane. Immature.
3	1·3490	28·9	11·46	
4	1·3510	29·0	12·72	
5	1·3510	29·0	12·72	
6	1·3523	29·0	13·57	
7	1·3540	29·0	14·72	
8	1·3530	29·0	14·07	Highest dead leaf.
9	1·3523	29·0	13·57	
10	1·3520	29·0	13·37	
11	1·3505	29·0	12·37	
12	1·3505	29·0	12·37	
13	1·3505	29·0	12·37	Lowest fully green leaf.
14	1·3485	29·0	11·12	
15	1·3465	29·0	9·77	
			SARETHA.	
1	1·3595	29·2	18·13	Maturing.
2	1·3590	29·2	17·83	
3	1·3587	29·2	17·68	
4	1·3600	29·3	18·44	
5	1·3605	29·3	18·74	
6	1·3603	29·3	18·59	
7	1·3603	29·2	18·58	
8	1·3595	29·1	18·12	
9	1·3582	29·0	17·32	
10	1·3605	29·0	18·72	
11	1·3615	29·0	19·32	
12	1·3620	29·0	19·67	
13	1·3630	29·0	20·22	
14	1·3615	29·0	19·32	
15	1·3632	29·0	20·37	
16	1·3625	29·0	19·92	
17	1·3622	29·0	19·77	
18	1·3612	28·8	19·11	
19	1·3620	28·8	19·66	Highest dead leaf.
20	1·3620	28·8	19·66	Half dead leaf.
21	1·3615	28·8	19·31	Carried fully dead leaves.
22	1·3610	28·5	18·99	
23	1·3610	28·5	18·99	
24	1·3605	28·4	18·68	
25	1·3595	28·3	18·07	Fully green leaf.
26	1·3590	28·3	17·77	
27	1·3560	28·3	15·87	
28	1·3540	28·3	14·67	
29	1·3505	28·3	12·32	
30	1·3470	28·3	10·07	
			CHEN.	
1	1·3625	28·2	19·86	
2	1·3625	28·2	19·86	Cane maturing.
3	1·3620	28·2	19·61	
4	1·3622	28·4	19·72	

TABLE II.—(*Contd.*)

No of internode from base	Observed n_D	Observed temp. °C	Total solids calculated as sugar at 28°C. %	REMARKS
		CHEN.—*Concld.*		
5	1·3622	28·5	19·73	
6	1·3622	28·3	19·72	
7	1·3625	28·3	19·87	
8	1 3623	28·3	19·77	
9	1·3615	28·3	19·27	
10	1·3610	28·2	18·97	
11	1·3615	28·3	19·27	Cane when cut open was found pitty.
12	1·3615	28·3	19·27	
13	1·3595	28·3	18·07	
14	1·3585	28·2	17·46	
15	1·3615	28·2	19·26	
16	1·3631	28·2	20·21	
17	1·3620	28·2	19·61	Highest dead leaf.
18	1·3605	28·0	18·65	
19	1·3600	28·0	18·35	
20	1·3600	28·0	18·35	
21	1·3575	28·0	16·80	
22	1·3545	28·0	14·95	
23	1·3525	28·0	13·65	Lowest fully green leaf.
24	1·3500	28·0	12·00	
25	1·3475	28·0	10·40	
		SARETHA II.		
1	1·3625	26·7	19·76	Maturing.
2	1·3645	26·8	20·96	
3	1·3643	26·9	20·87	
4	1·3625	27·0	19·78	Crack.
5	1·3622	27·0	19·63	
6	1·3629	27·0	20·03	
7	1·3632	27·1	20·23	
8	1·3635	27·2	20·39	
9	1·3646	27·4	21·06	
10	1·3646	27·4	21·06	
11	1·3645	27·5	21·01	
12	1·3645	27·5	21·01	
13	1·3635	27·7	20·43	
14	1·3632	27·7	20·28	
15	1·3638	27·8	20·64	
16	1·3652	27·8	21·44	
17	1·3635	27·9	20·44	Highest dead leaf
18	1·3635	27·9	20·44	
19	1·3628	27·9	20·04	
20	1·3628	28·0	20·05	
21	1·3605	28·0	18·65	
22	1·3610	28·0	18·95	
23	1·3610	28·0	18·95	
24	1·3590	28·0	17·75	
25	1·3590	28·0	17·75	Lowest fully living leaf.
26	1·3590	28·0	17·75	
27	1·3555	28·0	15·60	
28	1·3510	28·1	12.65	
29	1·3481	28·1	10·80	

TABLE II.—(*Concld.*)

No. of internode from base	Observed n_D	Observed temp. °C.	Total solids calculated as sugar at 28°C. %	REMARKS
		BHAROKAH.		
1	1·3568	29·5	16·51	Cane maturing.
2	1·3566	29·5	16·36	
3	1·3565	29·5	16·31	
4	1·3565	29·5	16·31	
5	1·3565	29·5	16·31	
6	1·3560	29·5	15·96	
7	1·3545	29·5	15·06	
8	1·3545	29·5	15·06	
9	1·3545	29·5	15·06	
10	1·3550	29·5	15·36	
11	1·3535	29·5	14·41	
12	1·3545	29·4	15·05	
13	1·3545	29·2	15·04	
14	1·3543	29·2	14·94	
15	1·3537	29·2	14·54	
16	1·3545	29·2	15·04	
17	1·3540	29·2	14·74	
18	1·3550	29·2	15·34	
19	1·3555	29·1	15·68	
20	1·3560	29·1	15·93	
21	1·3565	29·0	16·27	
22	1·3570	29·0	16·57	
23	1·3575	29·0	16·87	
24	1·3565	29·0	16·27	
25	1·3580	29·0	17·17	
26	1·3583	29·0	17·37	
27	1·3563	29·0	16·12	
28	1·3555	29·0	15·67	
29	1·3545	29·0	15·02	
30	1·3535	28·9	14·37	Highest dead leaf.
31	1·3510	28·9	12·72	
32	1·3500	28·8	12·06	
33	1·3485	28·8	11·11	
34	1·3475	28·8	10·46	
35	1·3465	28·8	9·76	Lowest fully green leaf.
36	1·3435	28·6	7·75	
37			No juice	
38			No juice	

TABLE III.

Showing results of refractometric examination of sugarcane varieties at regular intervals of one month during the period of their growth.

, of iter- ode om tom	Total solids calculated as sucrose at 28°C. %				No. of inter-node from bottom	Total solids calculated as sucrose at 28°C. %			
	2-12-15	5-1-16	8-2-16	8-3-16		3-12-15	7-1-16	9-2-16	9-3-16
	B. 208.					YERBA.			
1	22·95	23·31	23·17	22·23	1	21·07	22·57	22·56	21·02
2	22·42	23·31	23·17	23·13	2	20·33	22·57	22·75	21·02
3	22·23	23·01	23·27	22·78	3	20·49	22·27	22·63	21·27
4	21·96	22·76	23·48	23·17	4	20·14	22·57	22·93	21·57
5	21·70	22·75	23·21	23·17	5	19·09	22·57	22·94	21·87
6	20·29	23·01	23·31	22·82	6	18·99	22·57	23·32	22·42
7	20·74	22·76	23·51	22·52	7	20·14	22·57	23·57	23·02
8	18·35	22·41	23·72	22·82	8	18·09	21·99	22·94	23·62
9		22·76	23·53	23·21	9		21·99	21·82	23·32
10		22·43	23·74	23·46	10		21·39	22·13	22·36
11		22·43	23·84	23·46	11			22·68	22·76
12		21·58	23·99	23·21	12			23·91	23·36
13		20·73	24·14	23·06	13			24·51	23·86
14			23·84	23·21	14			24·21	24·96
15			23·84	23·28	15			23·36	24·26
16			23·54	23·38	16				24·56
17			23·24	23·53	17				23·99
18				23·83					
19				24·13					
20				23·83					
21									

TABLE III.—(*Contd.*)

No. of inter-node from bottom	Total solids calculated as sucrose at 28°C. %				No. of inter-node from bottom	Total solids calculated as sucrose at 28°C. %			
	9-12-15	6-1-16	10-2-16	9-3-16		10-12-15	17-1-16	12-2-16	10-3-16
	MOGALI.					PURPLE MAURITIUS.			
1	19·79	21·67	20·80	20·43	1	19·64	23·34	23·32	23·10
2	19·80	21·69	20·80	20·73	2	19·38	24·02	23·92	22·85
3	19·32	21·69	21·38	21·08	3	20·05	24·04	24·22	22·50
4	17·52	21·69	21·39	21·32	4	19·85	24·04	24·52	22·85
5	18·12	21·39	21·69	21·62	5	19·78	24·07	25·12	22·70
6	18·12	21·12	21·99	21·93	6	19·38	26·11	25·67	22·52
7	16·12	20·52	22·26	21·93	7	18·59	27·01	26·31	22·39
8	16·27	20·52	22·26	22·23	8		27·27	27·21	22·54
9	16·27	20·52	22·26	22·24	9		27·03	27·46	22·91
10		20·52	22·57	22·23	10		27·03	27·76	23·17
11		20·52	22·57	22·23	11			27·21	24·07
12		20·52	22·93	22·48	12			26·91	24·41
13		20·52	23·21	22·78	13			26·31	25·01
14			22·84	22·68	14			25·41	25·59
15			22·23	22·93	15				26·19
16			21·54	23·13	16				26·79
17			21·02	23·13	17				26·19
18			19·86	23·13	18				25·93
19			19·86	23·38	19				25·29
20			19·86	22·78	20				25·04
21				22·19	21				24·44
22				21·89					

TABLE III.—(*Contd.*)

No. of internode from bottom	Total solids calculated as sucrose at 28°C. % 10-12-15	17-1-16	11-2-16	11-3-16	No. of internode from bottom	Total solids calculated as sucrose at 28°C. % 12-12-15	19-1-16	11-2-16	12-3-16
Red Sports of Striped Mauritius.					Java Hebbal				
1	18·42	18·71	20·13	20·10	1	20·78	17·85	18·61	19 23
2	18·70	18·65	20·32	20·27	2	20·20	21·35	19·86	19·88
3	18·40	19·28	20·42	20·07	3	19·92	21·35	20·11	19·88
4	17·92	19·28	20·43	20·07	4	19·93	21·35	20·41	19·53
5	17·67	19·64	20·73	19·82	5	20·83	22·51	20·71	19·57
6	17·55	19·86	21·08	19·50	6	20·83	22·52	21·31	19·31
7	17·55	19·26	20·73	19·85	7	19·71	21·37	21·61	19·31
8		18·36	21·08	20·10	8	19·71	22·89	22·09	19·61
9		18·96	21·33	20·40	9		22·24	22·42	19·96
10		19·85	21·63	20·40	10		21·71	22·21	20·21
11		20·80	21·93	20·70	11		21·41	22·47	20·51
12		20·15	22·33	21·08	12		21·38	23·76	20·21
13		19·25	22·78	21·33	13		21·38	23·07	20·51
14			22·48	21·08	14		20·83	23·36	20·81
15			22·23	20·73	15			23·14	21·16
16			21·63	21·08	16			22·76	21·45
17			21·08	21·33	17			22·42	21·71
18			20·33	21·08	18			21·87	22·31
19			19·88	21·63	19			21·57	22·90
20				21·93	20			21·27	23·25
21				22·48	21			20·67	23·50
22				22·78	22				23·80
23				23·42	23				
24				22·82	24				
25				22·31	25				

TABLE III.—(*Contd.*)

No. of inter-node from bottom	Total solids calculated as sucrose at 28°C. %			
	18-12-15	20-1-16	17-2-16	17-3-16
	MAJORAH.			
1	18·06	18·55	18·62	18·63
2	17·97	18·55	18·62	18·63
3	17·67	18·25	18·63	18·63
4	17·93	18·55	18·93	18·63
5	18·18	18·28	18·93	18·63
6	18·28	17·98	19·23	18·63
7	16·93	17·98	18·93	18·44
8	15·84	17·71	19·23	18·34
9	15·88	17·71	19·22	18·04
10	14·95	17·72	19·52	17·94
11	14·62	17·74	19·31	17·77
12	14·62	17·75	19·49	17·77
13	14·35	18·05	19·88	18·07
14	14·03	18·35	19·53	18·17
15	13·71	18·05	19·23	18·37
16	13·22	17·75	19·49	18·67
17	12·12	17·10	19·84	18·97
18		17·10	19·84	19·21
19		16·50	19·94	19·31
20		15·85	20·09	19·46
21			19·84	19·61
22			19·14	19·96
23			19·14	20·21
24				19·96
25				19·61
26				19·31
27				19·01

No. of inter-node from bottom	Total solids calculated as sucrose at 28°C. %			
	22-12-15	20-1-16	18-2-16	16-3-1[illegible]
	KARIA.			
1	17·63	..	18·63	[illegible]
2	17·02	18·61	18·63	19·06
3	16·90	18·93	19·23	19·35
4	17·05	19·25	19·78	19·65
5	16·75	19·85	19·78	20·03
6	16·15	20·15	20·23	20·31
7	16·48	21·05	20·43	20·61
8	16·13	21·05	20·43	20·31
9	15·88	21·35	20·73	20·06
10	15·88	20·80	21·08	19·45
11	14·58	19·85	21·33	19·75
12			21·63	20·35
13			21·33	20·65
14				20·95
15				21·30
16				21·85
17				
18				

TABLE III.—(*Contd.*)

No. of inter-node from bottom	Total solids calculated as sucrose at 28°C. %				No. of inter-node from bottom	Total solids calculated as sucrose at 28°C. %			
	22-12-15	24-1-16	18-2-16	21-3-16		23-12-15	24-1-16	19-2-16	21-3-16
	KALUDAI BOOTHAN.					CHITTAN.			
1	19·28	19·71	20·13	22·09	1	21·51	23·80	23·62	23·47
2	18·69	20·56	20·43	22·38	2	21·41	24·70	24·22	23·20
3	19·28	20·59	20·73	22·38	3	22·04	24·40	24·22	22·97
4	18·97	20·58	21·08	22·38	4	22·48	24·40	24·55	23·24
5	18·07	19·98	21·07	22·38	5	23·10	24·10	24·25	22·99
6	17·47	20·56	21·32	22·68	6	22·85	24·38	24·55	22·65
7	17·48	20·52	21·31	22·68	7	22·51	24·17	24·66	22·35
8	17·45	20·84	21·59	22·42	8	21·99	24·34	24·35	22·65
9	16·50	21·12	21·59	22·76	9	21·08	24·32	24·55	23·06
10	16·50	19·92	21·89	22·48	10		24·60	24·83	23·32
11			22·09	22·23	11		24·90	24·92	23·63
12			21·89	22·23	12		24·30	25·12	24·08
13			21·29	21·93	13		23·40	25·37	24·55
14			20·69	22·46	14			25·02	24·89
15			20·09	22·78	15			24·82	25·19
16				23·12	16			24·22	24·59
17				22·47	17				23·39
18				21·92	18				22·79
19				21·33	19				22·24

TABLE III.—(*Contd.*)

No. of internode from bottom	Total solids calculated as sucrose at 28°C. %			
	23-12-15	25-1-16	25-2-16	24-3-16
	Fiji C.			
1	22·92	22·71	22·94	23·01
2	22·92	23·31	22·94	23·01
3	22·92	22·71	23·29	23·11
4	22·93	23·31	22·94	23·11
5	22·28	22·41	23·36	23·21
6	21·73	22·41	23·36	23·36
7		22·41	23·15	23·36
8		21·86	23·36	23·61
9		21·26	23·61	23·61
10			23·81	23·81
11			23·36	23·61
12			22·61	23·91
13			22·16	24·31
14			21·86	24·81
15			21·56	25·41
16			20·96	24·51
17				23·91
18				23·91
19				

No. of internode from bottom	Total solids calculated as sucrose at 28°C. %			
	23-12-15	25-1-16	24-2-16	23-3-
	Fiji B.			
1	22·30	24·61	24·36	24·47
2	22·29	24·61	24·74	24·15
3	22·17	23·74	24·44	24·21
4	22·02	24·07	23·14	23·91
5	21·72	22·59	23·84	24·21
6	21·12	22·97	23·54	23·91
7	20·87	22·63	23·84	23·61
8		22·33	24·14	23·36
9		21·79	24·44	23·01
10		21·49	24·74	22·71
11		21·49	25·14	22·46
12		21·49	25·59	22·16
13		21·19	26·24	21·55
14			25·89	21·85
15			25·59	21·55
16			25·04	22·15
17			24·44	22·45
18			23·84	22·75
19			23·54	23·60
20			22·94	23·36
21				23·91
22				24·51
23				24·81
24				24·21
25				23·61
26				23·01
27				22·71

TABLE III.—(*Contd.*)

BODI.

No. of inter-node from bottom	Total solids calculated as sucrose at 28°C. % 29-12-15	26-1-16	26-2-16	March
1	..	..	..	No juice could be extracted by the needle.
2	..	..	..	
3	15·63	..	..	
4	15·29	..	..	
5	15·01	17·82	..	
6	14·92	17·82	17·91	
7	15·02	18·15	18·11	
8	15·02	18·15	17·91	
9	15·02	18·18	18·25	
10	14·77	17·88	17·95	
11	14·37	17·58	18·15	
12	14·07	17·58	18·25	
13	15·02	17·88	18·00	
14	13·72	17·58	18·25	
15	13·78	17·89	18·40	
16	14·06	18·19	18·55	
17	14·36	18·19	18·55	
18	14·05	18·79	18·25	
19	14·03	19·09	18·25	
20	13·33	19·09	18·25	
21	12·66	19·39	18·25	
22	12·65	19·09	18·55	
23		18·49	18·55	
24		18·19	19·15	
25		17·49	19·45	
26			19·75	
27			19·30	
28			18·85	

YUBA.

No. of inter-node from bottom	Total solids calculated as sucrose at 28°C. % 30-12-15	28-1-16	25-2-16	March
1	19·03	..	..	No juice could be extracted.
2	19·09	..	..	
3	19·74	..	..	
4	19·41	18·99	18·48	
5	19·09	18·09	18·18	
6	18·79	18·41	18·18	
7	18·79	18·42	18·22	
8	18·49	18·72	18·32	
9	19·39	19·02	18·18	
10	19·09	19·05	18·48	
11	18·79	19·35	18·78	
12	18·19	19·39	19·08	
13	18·19	19·09	18·78	
14	17·89	19·39	19·08	
15		19·74	19·38	
16		19·09	19·68	
17		19·09	20·03	
18		18·49	20·23	

TABLE III.—(*Contd.*)

CHENI.

No. of inter-node from bottom	Total solids calculated as sucrose at 28°C. % 31-12-15	27-1-16	4-3-16	March
1	16·02	17·55	19·23	No juice could be extracted in the fourth month.
2	16·02	17·20	18·93	
3	16·02	17·20	18·11	
4	15·40	16·90	18·75	
5	15·42	17·20	19·08	
6	15·07	17·52	19·08	
7	15·06	18·09	18·78	
8	14·09	18·39	18·97	
9	12·70	18·65	19·13	
10	12·10	18·95	19·30	
11		18·35	19·40	
12		18·05	19·30	
13		17·45	19·40	
14			19·75	
15			20·10	
16			19·45	
17			18·55	
18			17·60	
19				
20				
21				
22				

NARGORI.

No. of inter-node from bottom	Total solids calculated as sucrose at 28°C. % 30-12-15	29-1-16	6-3-16	Ma
1	19·91	..	..	
2	18·26	..	..	
3	17·66	..	..	
4	17·66	..	..	
5	17·51	..	..	
6	17·31	17·59	..	
7	17·01	17·59	..	
8	16·98	17·24	17·52	
9	16·02	17·59	17·55	
10	16·37	18·19	17·55	
11	16·67	17·59	17·24	
12	16·01	17·24	17·24	
13	16·64	16·94	17·59	
14	17·59	16·94	17·80	
15	16·94	16·64	17·93	
16	16·34	16·84	17·94	
17	15·33	16·94	17·87	
18	15·32	17·24	17·97	
19	15·02	17·59	17·67	
20	14·69	17·94	17·87	
21	14·33	17·89	18·01	
22	12·92	18·19	18·00	
23	12·30	18·49	18·31	
24	10·40	17·89	18·48	
25	10·03	17·24	18·63	
26	9·04	17·59	18·78	
27		16·94	18·63	
28		15·99	18·93	
29			18·93	
30			19·13	
31			18·93	
32			18·63	

TABLE III.—(*Concld.*)

of er- ie m om	Total solids calculated as sucrose at 28°C. %				No. of inter-node from bottom	Total solids calculated as sucrose at 28°C. %			
	31-12-15	27-1-16	7-3-16			24-12-15	25-1-16	24-2-16	25-3-16
	CHIN. (*Aligarh.*)					J. 247.			
1	19·25	..	..	No juice could be extracted.	1	21·51	21·90	21·88	21·72
2	19·25	..	..		2	20·95	21·88	21·58	21·22
3	19·25	18·96	..		3	20·70	21·27	21·60	21·12
4	19·61	19·26	..		4	20·35	21·01	21·60	21·72
5	19·25	18·95	18·93		5	19·78	20·35	21·30	21·75
6	19·85	19·25	18·93		6	19·63	19·78	21·30	21·17
7	19·59	19·60	19·23		7	19·18	19·43	21·05	20·59
8	19·59	19·85	19·53		8	20·40	19·15	20·72	19·74
9	19·24	20·15	19·87		9	16·50	19·15	20·43	19·09
10	19·59	19·85	19·51		10	16·20	18·83	19·71	18·23
11	19·24	20·15	19·86		11	15·85	18·83	19·91	18·53
12	19·24	20·45	20·11		12	15·85	18·48	19·56	18·27
13	18·95	20·80	20·37		13	14·91	18·23	19·27	18·27
14	18·65	20·45	20·22		14		18·23	18·67	17·32
15		20·80	20·33		15		17·63	18·36	17·02
16		20·15	20·03		16			18·11	16·42
17		21·05	20·29		17			17·46	15·82
18		20·80	20·29		18			17·06	15·82
19			20·59		19			16·41	15·82
20			20·94		20				16·07
21			21·19		21				15·47
22			21·49						
23			20·94						
24			20·29						
25			19·09						

THE EFFECT OF SALINITY ON THE GROWTH AND COMPOSITION OF SUGARCANE VARIETIES.

BY

K. KRISHNAMURTI ROW, D. AG.,

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DURING 1913, in a portion of Block II (Fields Nos. 3, 12 and 1 of the newly acquired Cane-breeding Station, Coimbatore, som sugarcane varieties and seedlings were planted. Of the thic cane varieties, imported or local, many died, and the few that can up were very unhealthy with pale or yellow leaves, and had a stunte growth. The North Indian thin indigenous cane varieties came u better, but not to the standard expected (Plate IX). Our seedli canes too fared no better on this piece of land, though on a portio of Block I (Field No. 7) the same seedlings came up satisfactoril To study the causes of the unsatisfactory growth of canes in Block I and to find out what sort of varieties come up and what not, Fie No. 3, as representing Block II, was set apart, and on small plo of it year after year some varieties and seedlings were grown und the same conditions as existed when the estate was taken over.

GROWTH OF CANES IN BLOCKS I AND II COMPARED.

As a result of our experiments during the years 1914-18, may be stated that thick juicy varieties as a rule do not come up Block II (Field No. 3). Below is given a list of varieties that fail to grow and of those that came up well.

ALKALINE PLOT, 1914-15, 7½ MONTHS OLD.

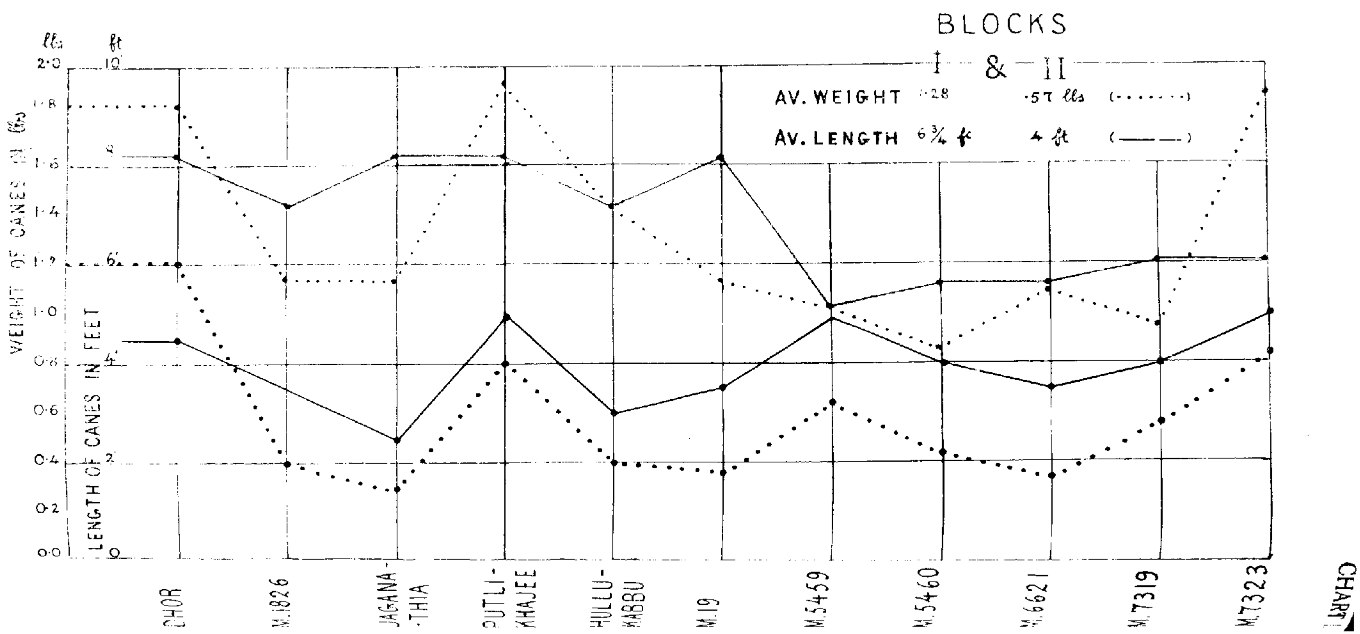
an Chittan K. Boothan Poovan J. 36 B. 208

Thick Canes

Cheni Naanal Teru Katha Chin Saretha

Thin Canes.

GROWTH OF CANES IN BLOCKS I & II (SALINE)



CHART

Block II (Field No. 3) irrigated by Well No. 3 (saline water).

VARIETIES THAT FAILED TO GROW.	THEIR GENERAL CHARACTERISTICS.
arun, Chittan, Kaludai Boothan, Poovan, B. 208, Purple Mauritius, Magh, Bogapura, J. 36 and D. 74.	These are soft, thick canes containing from 10 to 15 per cent. of fibre, 15 to 20 per cent. of sucrose, and giving 65 to 75 per cent. of juice.
VARIETIES THAT CAME UP FAIRLY WELL.	
eni, Naanal, Katha, Saretha, Putli Khajee, Hullu Kabbu, M. 1017, Jagannathia, Dhor (Seoni), M. 1826, M. 19 and M. 2104.	These are harder, thinner canes, contain from 15 to 20 per cent. of fibre, 13 to 16 per cent. of sucrose, and give 40 to 55 per cent. of juice.

In order to make a detailed study of the differences in growth, tc., of canes in Block II (Field No. 3) and in Block I (Field No. 7), alf a dozen varieties which had done well in Field No. 3 were chosen. hey were planted and harvested on the same date on both the elds and their after-cultivation was also similar. The growth, tc., of the above varieties are hereunder compared. (Chart I.)

Variety	Block I					Block II				
	Stand	Length	Thickness	Av. wt.	Habit	Stand	Length	Thickness	Av. wt.	Habit
		ft.	cm.	lb.			ft.	cm.	lb	
Dhor (Seoni) ..	Full stand and medium vigour	8	2·35	1·80	Old canes curved, young canes straight	Nearly full and vigorous	4·5	2·20	1.20	Straight
M. 1826 ..	Full and rather vigorous	7	1·80	1·10	Straight below, and slightly curved at top	⅔ stand and medium vigour	3·5	1·80	0·40	Straight below, and slightly curved above
Jagannathia ..	Full and vigorous	8	1·75	1·10	Badly curved	Nearly full and medium vigour	2·5	1·65	0·30	Straight
Putli Khajee ..	Nearly full and medium vigour	8	2·30	1·90	Straight below, and curved at top	½ stand and fair vigour	5·0	2·30	0·80	Do.
Hullu Kabbu	Full and vigorous	7	2·00	1·40	Slightly curved	½ stand and medium vigour	3·0	not noted	0·40	Do.
M. 19 ..	Full and rather vigorous	8	1·65	1·10	Badly curved	½ stand and medium vigour	3·5	1·60	0·36	Do. but curved
Rogues.*										
5459 ..	Full stand and vigour	5	2·00	1·0[illegible]		¾ stand and medium vigour	5·0	1·70	0·63	
5460 ..	Do. ..	5½	2·20	0·83		Do. ..	4·0	1·75	0·43	
6621 ..	Do. ..	5½	2·00	1·08		Do. ..	3·5	1·60	0·34	
7319 ..	Do. ..	6	1·90	0·94		Do. ..	4·0	1·65	0·56	
7323 ..	Do. ..	6	2·40	1·88		Do. ..	5·0	1·90	0·84	
Average ..	..	6¾	2·00	1·28		Do. ..	4·0	1·80	0·57	

PLATE

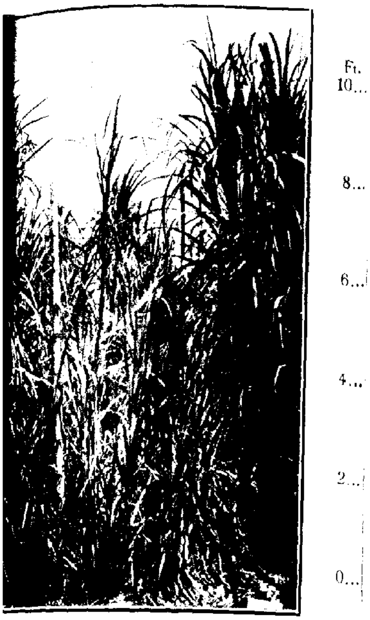
SALINE PLOT (BLOCK II), 1915-16.

Dhor Kina Saretha Chin Nargori

o. 21 M. No. 19 Putli Khajee Ekar Katha.

PLATE X

LESS SALINE PLOT (BLOCK I), 1915-16.



Saretha.

Chin.

Putli Khajee.

Katha.

From the above, it will be seen that cane varieties in Block I re one and a half times as tall and twice as heavy as those own on Block II. In Block I the plants were more vigorous and l full stand, and, as already noted, thick cane varieties (Vellai, 74, etc.) which do not come up at all in Block II come up in Block I isfactorily. (Plates X and XI.)

Reasons for the differences in growth.

The reasons for the poor growth of cane varieties in Block II ield No. 3) will be made clear if we compare the composition of the l and irrigation water of that field with that obtained on Block I.

Analysis of soil and sub-soil of Blocks I and II.

	Block I		Block II	
	Surface soil	Sub-soil	Surface soil	Sub-soil
l. carbonate	0·018	0·009	0·018	0·018
g. carbonate	0·004	0·004	0·008	0·008
d. carbonate	0·001	0·008	0·003	..
d. sulphate	0·011	0·006	0·024	0·002
d. chloride	0·021	0·012	0·061	0·053
Total solids ..	0·085	0·070	0·170	0·140

Examination of layers of soil in pits dug in Blocks I and II.

Soil	Block I	Block II
	Fine red silt uniform throughout	Blackish, fairly stiff soil containing at a depth of about 2′ from the surface a hard layer of stiff soil incapable of free drainage.
Average percentage of chlorine in the 6 layers.	0·03	0·17
Average percentage of total solids in the 6 layers.	0·16	0·47

From the above analyses of soil, sub-soil and of pits, it will be seen that in Block II the percentage of sodium chloride in the surface

layers is more than three times that of Block I, and in deeper layers of pits it is worse still, containing nearly six times that of Block I. But for this sodium chloride, other salts present are not in any great excess in Block II.

Composition of well waters of Blocks I and II.

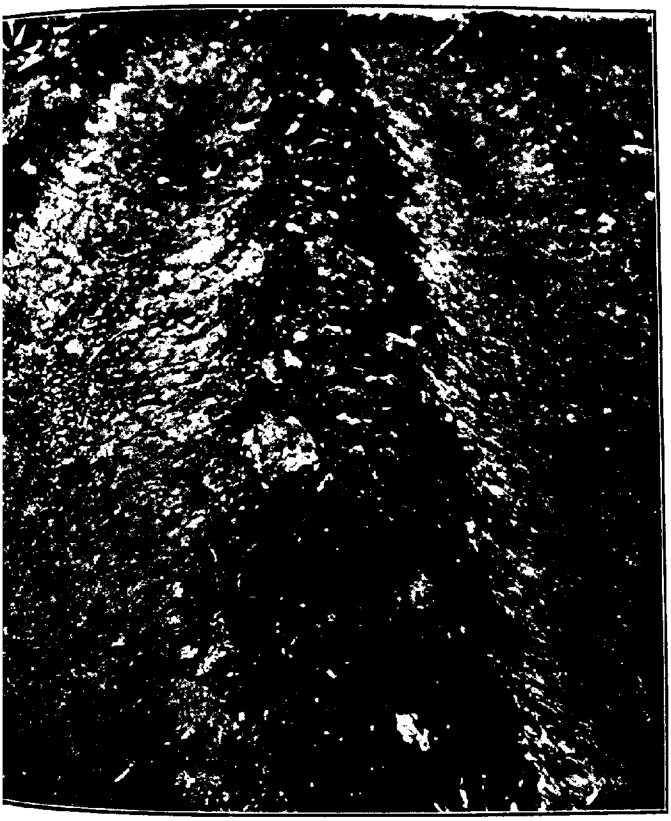
	Block I (Well No. 1)	Block II (Well No. 3)
	(In 100,000 parts of water)	
Cal. carbonate	21·42	26·80
Mag. carbonate	9·07	29·55
Sod. carbonate	10·39	....
Mag. sulphate	....	11·85
Sodium sulphate	10·37	48·16
Sodium chloride	32·58	188·98
Total solids (by evaporation) ..	91·00	342·00
Total injurious salts	53·34	248·99

The presence of 188·98 parts of sodium chloride in 100,000 parts is certainly very high and should have been the chief cause for the poor growth of canes observed in Block II (Field No. 3). It is observed in an article by the author on "well waters" in the *Madras Agricultural Students' Union Journal* (pages 26–28, January, 1914) that canes grown under a well containing more than 70 parts of sodium chloride at Samakulam Agrahāram were not doing so well as those which contained smaller quantities of the above salt. The evil effect of irrigating lands with such saline water, especially when the soil is fairly stiff as in Block II, is to produce an efflorescence of a peculiar kind of soft brownish earth, very powdery, on the sides and tops of ridges(*see* Text-figure). This kind of efflorescence was practically absent in Block I. The powdery earth was carefully scraped, sampled and analysed with the following result :—

Analysis of the saline efflorescence found in Block II.

	per cent.
Lime (CaO)	1·10
Magnesia (MgO)..	0·43
Potash (K_2O)	0·02
Carbonic acid (CO_2)	0·01
Sulphuric acid (SO_3)	0·57
Chlorine (Cl)	3·83
Nitrates (by Nitrometer)	0·43

The above analysis confirms that the chief cause for the bad wth of cane in Block II is chlorine.



Saline efflorescence in Block II.

It may be interesting to note in this connection that an analysis of the water that was dripping from the other end of cane on crushing, showed that 60 per cent. of the soluble ash was sodium chloride (*vide* page 390 (1915) of the ***Madras Agricultural Students' Union Journal***).

If we now take into consideration all the above factors which go to smother the growth of cane in Block II (Field No. 3), it may be inferred that the chief source of all our troubles is the nature of irrigation water of Well No. 3, and that the chief injurious ingredient of this water is chlorine. Other contributory causes, *viz.*, saline nature of soil layers in pits, the very badly saline nature of the efflorescence, etc., may all be traced to this bad irrigation water. The indifferent drainage of Field No. 3, due to the presence of a hard stiff layer at a depth of about two feet, may have also contributed to the bad growth.

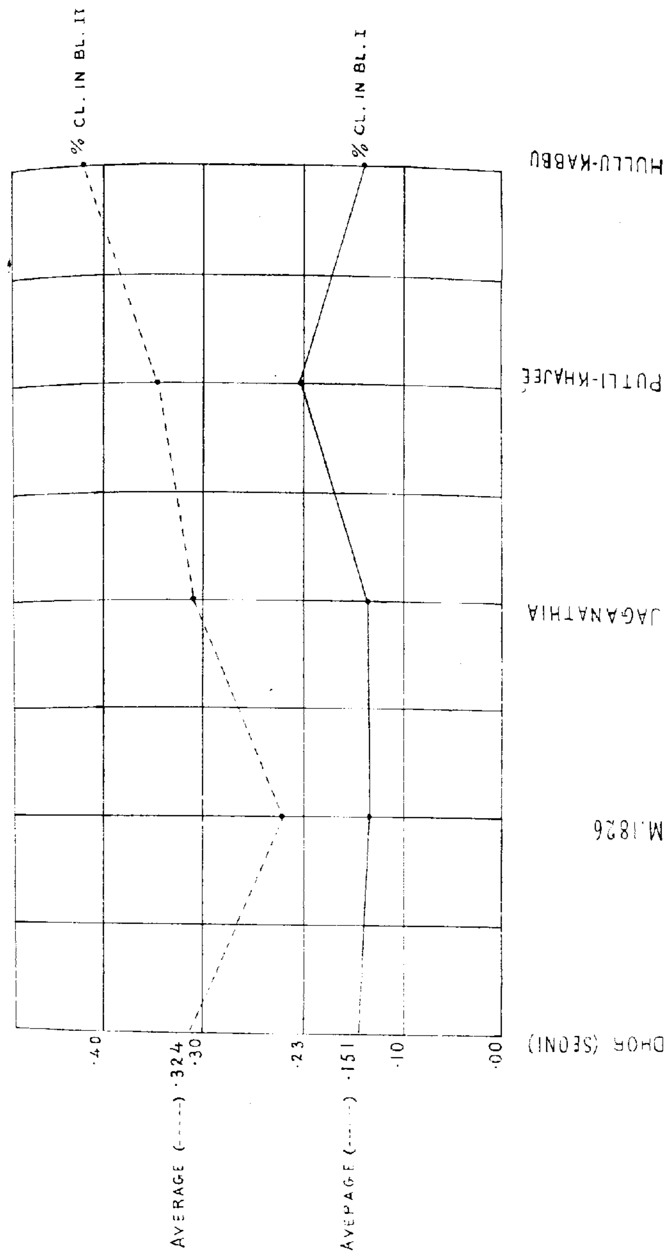
Effect of saline conditions on the ash of cane juices.

To determine how the saline conditions above referred to affect the composition of sugarcane juices, the following experiments were made. One hundred c.c. each of the juices of Cheni, Teru, and Katha varieties were evaporated to dryness and ignited. The quantities of inorganic salts found in the above are given below :—

Particulars	Varieties		
	Cheni	Teru	Katha
Lime	0·023	0·037	0·035
Magnesia	0·067	0·083	0·074
Phosphoric acid	0·079	0·059	0·081
Sulphuric acid	0·132	0·062	0·087
Chlorine	0·266	0·234	0·355
Potash	0·350	0·314	0·395
Undetermined	0·058	0·079	0·160
Total percentage of ash ..	0·975	0·868	1·187

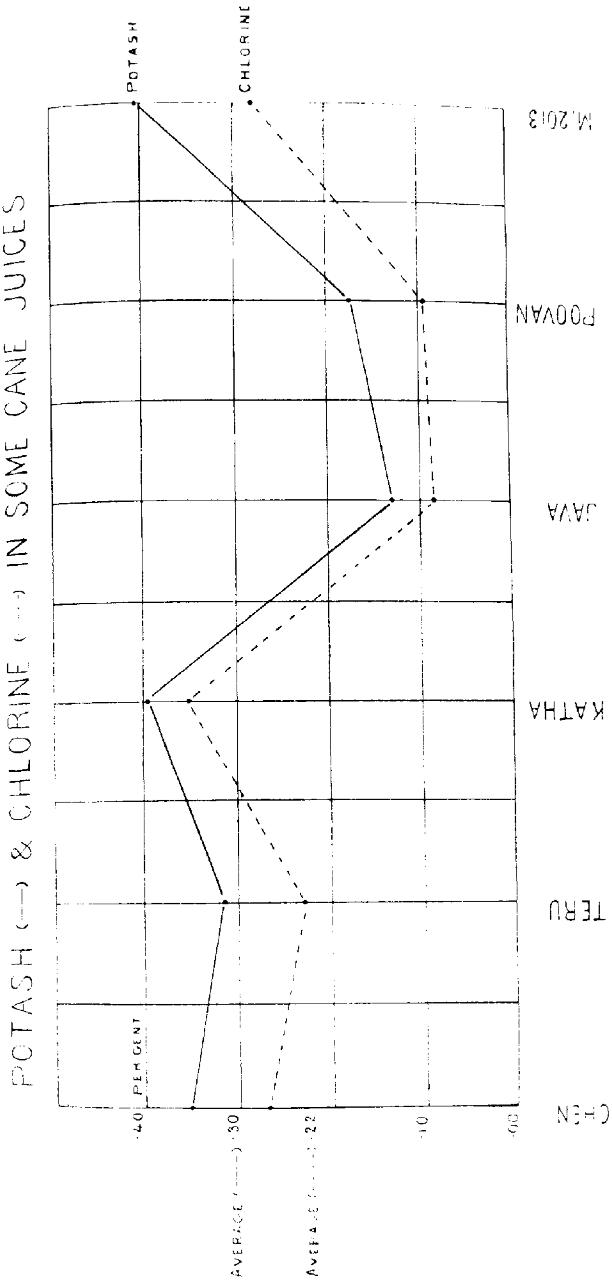
The above analysis gives one an idea of the large percentage of chlorine in the juices of canes grown under saline conditions.

CHART I



% CL. IN BL. II
% CL. IN BL. I
HULLU-KABBU
PUTLI-KHAJEE
JAGANATHIA
M.1826
DHOR (SEONI)
·40
·324
·30
·23
·151
·10
·00
AVERAGE (----) ·324
AVERAGE (——) ·151

CHART III.


POTASH (—) & CHLORINE (---) IN SOME CANE JUICES
POTASH
CHLORINE
M.2013
POOVAN
JAVA
KATHA
TERU
CHEN
PER CENT
·40
·30
·22
·10
·00
AVERAGE (——) ·30
AVERAGE (----) ·22

ow these same varieties would fare if grown under better conditions uld not be ascertained, as we had no duplicate plot then. In the ar 1917-18, as already noted, we had a duplicate plot of Block I. low is given a comparison of the chlorine contents of the same rieties grown under different conditions (Chart II).

Varieties	Block I		Block II	
	Total solids	Chlorine	Total solids	Chlorine
ior (Seoni)	0·707	0·144	0·918	0·316
1826	0·765	0·135	0·810	0·218
gannathia	0·846	0·136	0·959	0·313
tli Khajee	0·955	0·204	1·073	0·346
llu Kabbu	1·039	0·138	1·139	0·426
Average ..	..	0·151		0·324

From the above it will be seen that the average percentage f chlorine obtained in the ash of cane juices of varieties grown nder saline conditions is more than double that obtained in the uplicate plot (Block I). Again, a reference to the detailed analysis f ash shows that juices which are highly charged with chlorine lso contain a high percentage of potash (Chart III).

	Chlorine	Potash
Cheni	0·266	0·350
Teru	0·234	0·314
Katha	0·355	0·395

Figures of further analyses made to confirm the above results re

Java	0·088	0·14
Poovan	0·095	0·18
M. 2013	0·280	0·41

The presence of chlorine in the juices, as already mentioned, is due to the large amount of that element in irrigation water and in the soil. But the presence of large percentages of potash in the juices is not so easily explained. Fortunately, this question has been tackled by Geerligs (page 586, *Inter. Sugar Journal*, 1905), and his investigations on the influence of soda salts on the constitution of sugarcane afford the necessary explanation. His conclusions are :

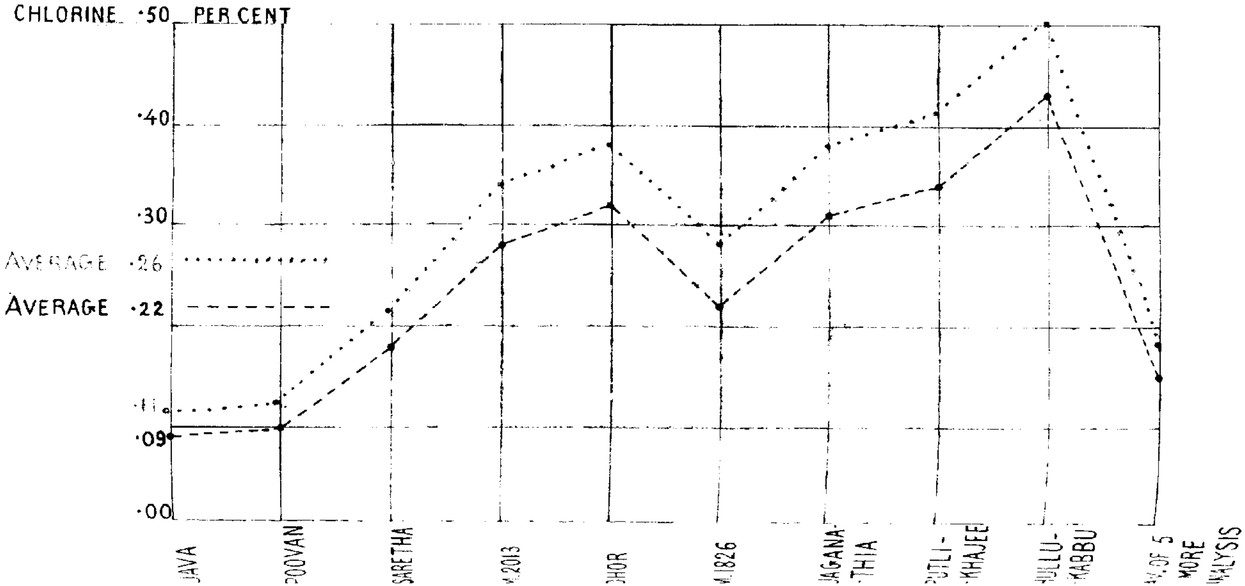
"From these investigations we draw the conclusion that sodium chloride extracts potash, lime and magnesia from the soil, and puts these at the disposal of plants; and next, that sugarcane assimilates in the first place the potash, in a much inferior degree lime and magnesia, and finally, if there is nothing else to be had, also soda, etc." Thus the presence of potash in a marked degree in the juices of canes grown under saline conditions has been traced to be due to sodium chloride present in large quantities in irrigation water and in the soil, and as large quantities of potash co-exist with large quantities of chlorine, it suggests itself that an analysis of any one of the above ingredients may give one an idea of the quantity of the other.

The determination of potash is not easy and entails tedious processes; so the choice fell on chlorine. Even in this, the usual method of determination—evaporating the juice to dryness, igniting the same and then titrating the water extract against silver nitrate solution—is not quite feasible in an ordinary field laboratory. Again as sugarcane juices are generally acid in reaction and also turbid without neutralization and clarification, a sharp end reaction with silver nitrate solution cannot be obtained. The usual basic lead acetate cannot be used for clarification purposes, as chlorides present in the juice will be precipitated as lead chloride. After many trials, the following method that is found to give fairly satisfactory results was adopted.

Direct method of determining chlorine in cane juices.

Fifty c.c. of the sugarcane juice to be examined were measured out into a 100 c.c. measuring flask, neutralized with pure lime water, 25 c.c. of alumina cream added, and the whole then made up to 100 c.c. with distilled water. This was then transferred to a beaker and kept covered on a sand bath for some time till albuminoids, etc., in the juice began to coagulate and settle down. On filtration the filtrate was found to be clear and ready for titration. For impure juices a small quantity

CHLORINE BY ALUMINA CREAM (.....) AND IGNITION (- - -) METHODS



f bone char may be necessary to ensure a clear filtrate. Twenty-ve c.c. of this filtrate—equivalent to 12½ c.c. of the original uice—were taken and titrated against decinormal silver nitrate olution.

The above method of determining chlorine directly in the uice saves much time and can be undertaken side by side with he usual juice analysis in any field laboratory where facilities for vaporating and igniting the juice do not exist. Though this method ives slightly higher percentages than that obtained by the ignition method, as will be seen hereafter, the results obtained give one a orrect idea of the relative quantity of chlorine in the juice—the main object aimed at.

THE USUAL IGNITION METHOD AND THE ALUMINA CREAM METHOD COMPARED.

To ascertain the differences in the value of chlorine obtained n the two methods, it was determined by the usual evaporation and ignition method at the chemical laboratory by one ssistant; and by the lime water alumina cream method at the Cane-breeding Station field laboratory by another with the following result (Chart IV):—

Chlorine obtained in 100 c.c. of cane juice.

Variety	Ignition method	Alumina cream and lime water method
Java	0·090	0·110
Poovan	0·095	0·120
Saretha	0·180	0·210
M. 2013	0·280	0·340
Dhor (Seoni)	0·316	0·381
M. 1826	0·218	0·285
Jagannathia	0·313	0·366
Putli Khajee	0·346	0·408
Hullu Kabbu	0·426	0·500
Average of a set of another 5* analyses of the above varieties in the duplicate plot.		
* Dhor (Seoni), M. 1826, Jagannathia, Putli Khajee, Hullu Kabbu.	0·151	0·179
Average of all the above..	0·216	0·258

It is seen that the percentage of chlorine obtained from e ignition method is about 16 per cent. less than that obtained

by the alumina cream method. As the ingredients used were pur
it is presumed that this may be due to the loss of a small quantity
chlorine in the ignition method by volatalization, and to the precip
tation of some other substances of the cane juice by silver nitra
in the direct method.

Having traced the poor growth of cane in Block II (Fiel
No. 3) to be due to the very badly saline conditions under whic
they were grown, and having shown that such canes contain in the
juices large percentages of chlorine, it is now proposed to compa
in a general way the amount of chlorine which the different varieti
are capable of taking from the soil and the effect of chlorine on th
sucrose, glucose, and purity of the cane juices.

THE AMOUNT OF CHLORINE ABSORBED BY DIFFERENT VARIETIES AND ITS EFFECT ON THE SUCROSE, GLUCOSE, ETC., OF CANE JUICES.

Chlorine contents of good thick juicy varieties under salin
conditions obtained in Block II could not be estimated, as they do nc
grow at all under such conditions. But to show in a rough way tha
they are not capable of absorbing much chlorine, I give below som
chlorine results of thick cane seedlings grown on Block I.

Thick cane seedlings and varieties.

Variety	Seedling No.	Silver nitrate required for 100 c.c. juice (by the alumina cream method)	Chlorine in 100 c.c. of juice
Karun	1313	36·8	0·13
	1279	26·0	0·09
	885	30·0	0·11
	1170	35·2	0·12
	1173	36·0	0·13
Chittan	485	27·2	0·10
	222	22·0	0·08
Java	....	....	0·09
Poovan	....	....	0·95
AVERAGE ..	....	30·5	0·11 This is equivalent to 0· by the ignition method.

SUCROSE (—) GLUCOSE (····) & PURITY (×××) OF CANES IN

BLOCKS I & II (SALINE)

	I	II
Av. Suc.	12·45	10·20
Av. GLU.	0·14	0·24
Av. PUR.	77·10	70·70

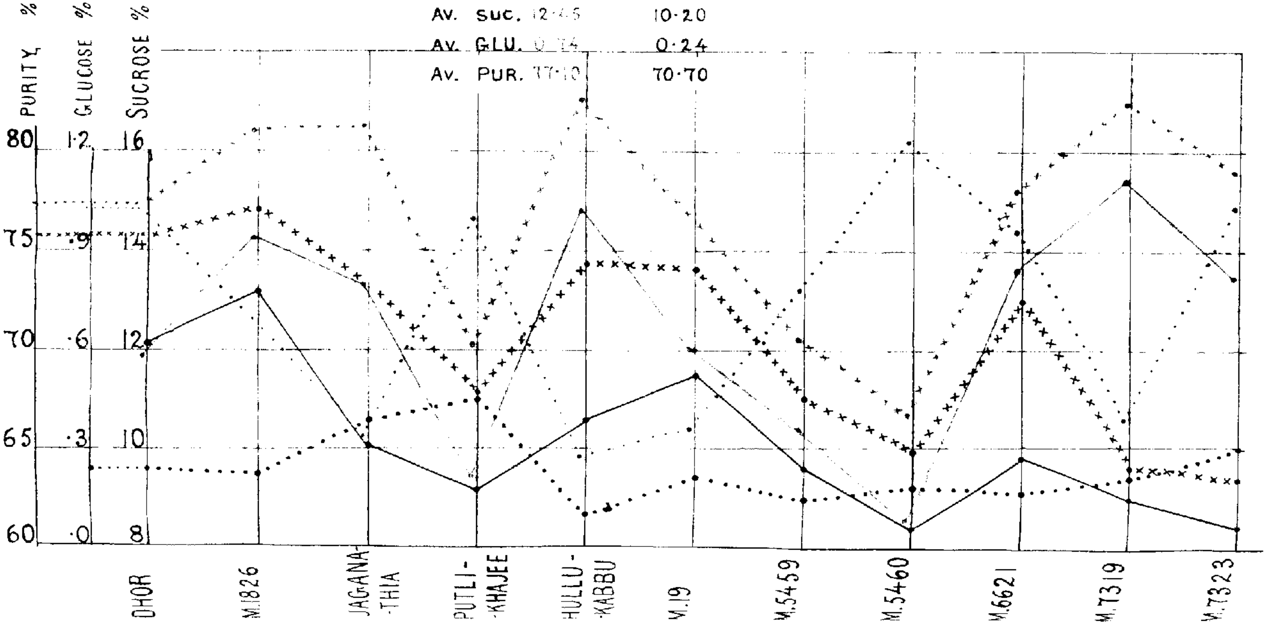


CHART V

Thin cane varieties.

			Chlorine in 100 c.c. of juice
ni ..	1914	Block II (Fields Nos. 12 & 13). No duplicate plot. Chlorine got by the ignition method	0·266
n ..			0·234
ha ..			0·355
nal ..	1915	Block II (Field No. 3). No duplicate plot. Chlorine by the alumina cream method	0·260
ni ..			0·330
ha ..			0·350
etha ..			0·370
1017 ..			0·420

As already noted, the amounts of chlorine absorbed by some rth Indian thin cane varieties under saline and sweet water nditions are given below :—

Varieties	BLOCK I (sweet water conditions)	BLOCK II (F. No. 3 saline conditions)
	Chlorine	Chlorine
or (Seoni)	0·144	0·316
1826	0·135	0·218
gannathia	0·136	0·313
tli Khajee	0·204	0·346
llu Kabbu	0·138	0·426
Ave age of all thin canes ..	0·151	0·340

From the above it could be roughly inferred—

(1) that thick juicy cane varieties absorb much less chlorine han thin hardy varieties;

(2) that chlorine contents of varieties to a great extent depend pon the nature of soil and of irrigation water under which they re grown;

(3) that different varieties absorb different amounts of chlorine ough grown under the same conditions.

From the figures given in the following tables it will be en that the effect of large quantities of chlorine in any juice to lower the values of sucrose, purity, as well as of glucose Chart V).

Sucrose.

Year	Seedling No. or variety	Block I	Block II
1913-14	17 ..	14·71	12·24
	19 ..	15·31	14·14
	25 ..	14·20	11·86
	26 ..	11·75	10·88
	27	14·76	11·96
	29	14·62	9·79
	30	14·14	15·99
	34 ..	14·79	10·49
	37 ..	11·68	9·84
	38 ..	15·84	13·42
	45 ..	16·19	14·57
	Average ..	14·36	12·29
1917-18	Dhor (Seoni)	11·78	12·11
	M. 1826	14·15	13·16
	Jagannathia ..	13·33	10·08
	Putli Khajee	9·40	9·23
	Hullu Kabbu ..	14·83	10·64
	M. 19	11·99	11·53
	5459	10·44	9·65
	5460	8·46	8·45
	6621	13·60	9·84
	7319	15·39	9·05
	7323	13·54	8·44
	Average ..	12·45	10·20

Out of 22 cases considered, in 20 cases the sucrose percentage is higher in the less saline plot (Block I) and the average percentage is higher by 2 per cent.

Glucose and co-efficient of purity.

Varieties and rogues	Block I		Block II	
	Glucose%	Purity	Glucose%	Purity
...r (Seoni)	1·02	77·0	0·23	75·5
...1826	0·70	80·8	0·22	76·9
...annathia	0·32	81·3	0·40	73·1
...li Khajee	0·98	70·4	0·45	67·8
...llu Kabbu	0·27	82·6	below 0·15	74·3
...19	0·36	76·6	0·21	74·2
...9	0·77	70·4	0·15	67·3
...0	1·22	66·7	0·19	64·8
...1	0·97	77·8	0·17	72·5
...9	0·38	82·3	0·21	63·9
...3	1·14	78·9	0·30	63·3
Average ..	0·89	77·1	0·29	70·7

It is natural to expect juices which contain larger amounts ... soluble salts and which give lower sucrose results to give lower ...efficients of purity. But the lower percentage of glucose obtained ... Block II was not quite expected. On the manufacturing side ...e effect of this low percentage of glucose in a juice which also ...ntains large quantities of soluble salts is undesirable; for this ...ondition would prevent crystallization of sucrose according to the ...searches conducted by Geerligs (*vide* pages 369 and 415. *Sugarcane*, ...895). This is due possibly to the large amount of soluble salts in ...he thin cane varieties with low percentages of glucose. The ...aggeries obtained at the Cane-breeding Station do not set well and ...un to liquid in course of time.

Experiments with gypsum were conducted in 1916-17 with the ...arieties mentioned below under saline (No. 3 well water) and sweet ...ater (No. 1 well water) conditions. Both the plots were planted between the 30th June and 3rd July, 1916, and both harvested between 28th June and 30th June, 1917. As the analytical results obtained confirm the previous results, they are noted below.

Variety	Sweet water conditions				Saline conditions			
	Av. wt.	Suc.	Glu.*	Purity	Av. wt.	Suc.	Glu.*	Purity
Putli Khajee ..	0·70	11·06	0·91	72·6	0·32	8·15	0·16	61·1
M. 19 ..	0·47	15·66	0·24	83·2	0·19	10·75	0·13	69·1
Hullu Kabbu ..	0·81	16·71	0·23	84·4	0·33	11·36	0·25?	70·9
Ekar ..	0·55	12·17	0·39	78·9	0·25	5·78	0·10	51·0
Dhaur Kinar ..	0·32	15·26	0·28	81·2	0·22	9·07	0·10	63·6
Average ..	0·57	14·17	0·41	80·0	0·26	9·02	0·15	63·1

* The glucose figures are the average of several determinations. The figures for individu cases are given below and they prominently bring out the fact of very low results obtain under saline conditions.

Putli Khajee ..	1·03	0·68	1·14	& below 0·81	below 0·15	below 0·15	0·18	0·24
M. 19 ..	0·28	0·25	0·34	& below 0·15	below 0·15	below 0·15	below 0·15	0·23
Hullu Kabbu ..	0·18	0·31	0·37	& below 0·15	below 0·15	below 0·18	below 0·15	0·65
Ekar ..	0·48	0·46	0·37	& 0·25	below 0·15	below 0·15	& below 0·15	..
Dhaur Kinar ..	0·43	0·26	0·25	& 0·20	below 0·15			

From the above, it will be seen that out of 20 determinatio only two gave below 0·15 per cent. of glucose under sweet water co ditions; whereas the same varieties under saline conditions gave belo 0·15 of glucose in 11 out of 16 determinations.

References to literature on the subject.

Geerligs: "Generally in sugar mills where chiefly a pure an rich cane is crushed the juices contain little potash, while in other where even the best ripened canes never rise above a comparativel low figure, large quantities of that element are to be found." (*Inter. Sugar Journal*, page 420, 1911.)

Hilgard : "The common beet (including the Mangel Wurze is known to succeed on saline seashore lands........Such bee are wholly unfit for sugar-making. They are also said to be bitte for stock."—(*California Bulls. 128 and 133.*)

Lehman: "Alkaline nature of a soil gives greater soluble ash canes which prevent sugar crystallizing out, and it makes the gar content also low."—(*Mysore, Third Annual Report.*)

Hilgard: "In grapes the sugar content seems to have throughout e tendency of decreasing with increasing strength of alkali."—*California Bulls. 128 and 133.*)

Leather: "The taste of the cane was distinctly saltish, showing at it is a salt-absorbing plant—a fact of some practical value. It ay be remarked that the presence of any large quantity of these alts in cane juice would make it useless for manufacturing purposes. he percentage of sugar in the cane appears to be below the verage."—(*Agri. Ledger*, 1901.)

Mann: "Sugarcane, when well manured and watered, is a rop very resistant to damage by salt, and, as a rule, when it will ot grow, the land can be used for little else."—(*Bom. Bull.* 39 of 1910.)

Note.—The above statement of Mann is rather exaggerated as we have been getting at he Cane-breeding Station good crops of *cholam* (*Sorghum*) and *ragi* (*Eleusine coracana*) in Block II (Field No. 3), where good thick canes do not come up at all, and where even the hin hardy canes only grow indifferently.

The results of experiments by Echart at Hawaii regarding the effect of salt in the irrigation waters are given below:—

Plot No.	Salt per gal. in irri. water	Lime added	Grs. of Cl. per gal. in juice	Sugar per acre
				lb.
1	None	No lime ..	9·80	25,648
2	200 gr.	Coral (powdered)	93·10	5,448
3	200 "	Gypsum ..	84·90	5,461
4	200 "	No lime ..	105·24	3,715

Note.—200 gr. in a gallon is equivalent to 286 parts in 100,000 parts of water.

100 gr. of chlorine per gallon is equivalent to 0·143 gr. of chlorine in 100 c.c. of juice, or quivalent to the amount of chlorine precipitated in 100 c.c. juice by about 40 c.c. of decinormal ilver nitrate solution.

From the above, it is seen that in a variety of cane containing about 100 grains of chlorine in a gallon of juice the outturn of sugar

per acre is very much reduced. Also the application of lime or gypsum to lands irrigated by saline waters has had very little effect either on the chlorine content or sugar per acre. The results obtained on the Cane-breeding Station with gypsum go to confirm the above statement.

Low quality jaggery obtained from North Indian canes at the Cane-breeding Station explained.

Our experience on the manufacturing side, *i.e.*, making *jaggery* from juices containing chlorine, are in conformity with the opinions expressed above. In a general way, it may be stated that on fields where the chlorine percentage is low, *e.g.*, Fields Nos. 9 and 24, we have been able to grow successfully thick cane varieties and have prepared from them fairly good *jaggery*. In other fields which were for a long time under saline irrigation before they were taken up by the Government Sugarcane Expert, the good varieties and seedlings which did not come up at all in 1913 are now coming up fairly well under sweet water irrigation and other improved methods of cultivation. The North Indian varieties and thin seedlings which were coming up indifferently before are coming up well now. But the *jaggery* obtained from North Indian cane varieties is still unsatisfactory. This shows that obtaining good quality *jaggery* does not depend upon the successful growth of canes only. The explanation for our getting unsatisfactory *jaggery*, especially from Fields Nos. 12 to 20, appears to be that those fields still contain in the surface or deeper layers of soil fairly large amounts of chlorine, and that North Indian varieties which have been shown to be more capable of absorbing chlorine than thick cane varieties take up sufficient chlorine to lower the quality of their juices and consequently give inferior kind of *jaggery*.

Summary.

Summarising the above it is found that—

(1) Soft, thick, juicy varieties do not come up at all in saline land (Block II, Field No. 3), while, thin hard and less juicy varieties come up fairly well.

(2) Sugarcane varieties and seedlings, which do not come up ell under saline conditions (Block II), come up far better under ss saline conditions (Block I), and this difference in growth is aced to be due chiefly to sodium chloride.

(3) The effect of saline irrigation is to give an impure juice ntaining large amounts of chlorine and potash, and that a etermination of chlorine alone, which is comparatively easy, will ve one an idea of the approximate quantity of the other.

(4) The usual method of determining chlorine—evaporating the ice, igniting the same and determining chlorine in the water xtract—not being found quite feasible in a field laboratory, a new ethod of directly determining chlorine in the juice by lime water nd alumina cream is suggested. This is found to give a correct lea of the relative quantity of chlorine in juices, and is also uicker and better adapted to a field laboratory.

(5) The chlorine content of a variety depends upon (*a*) conitions of soil, water, etc., under which it is grown, (*b*) nature f the variety itself.

(6) The effect of large quantities of chlorine in any juice is to ower the sucrose, purity, and glucose contents of that juice.

(7) A large percentage of soluble salts in the juices of canes grown under saline conditions is usually associated with a low glucose content and interferes with the crystallization of sucrose.

(8) The inferior kind of *jaggery* obtained on the Cane-breeding Station from North Indian cane varieties is due, among other factors, to the high chlorine content of the juices. Determination of chlorine in the juice would give one an indication of the relative quality of *jaggery* one is likely to get.

In conclusion, I beg to offer my grateful thanks to Dr. C. A. Barber, C.I.E., for giving me every facility and for guiding me with suggestions during the course of this investigation.

PROBABLE MATERIAL FOR THE STUDY OF THE EXPERIMENTAL EVOLUTION OF *ORYZA SATIVA*, VAR. *PLENA*, PRAIN.

BY

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Oryza sativa, var. *plena*, Prain, the "double grain paddy," is a variety of rice cultivated in Bengal. Agriculturally it cannot be said to be a desirable variety, but it nevertheless possesses an interesting botanical curiosity. This consists in the fact that though practically to all outward appearances it looks like an ordinary variety of rice (Plate XII, fig. 1), still usually a certain proportion of the spikelets in the panicle, instead of having a solitary grain, may contain two to five grains or so each. This is due to the fact that nearly every spikelet in the panicle contains two to five ovaries in the flowering stage (Plate XII, fig. 3). The number of well developed grains per spikelet, however, is often one to three only, as probably all the ovaries are not in a fit condition to be fertilized at once or, even if they are, there is scarcely room enough for them to be properly developed. This variety is not grown in the Bombay Presidency.

In a plot of this variety, grown at Alibag for the first time this year, it was found, in rare instances, that the topmost spikelets on a few branches of the panicle had only a single ovary with four or more stigmas, two or more ovaries being then united together. The number of stamens in each spikelet is usually six, but in rare instances it was found to be seven or eight, thus indicating a slight tendency in the stamens to increase their number. In a few instances

EXPLANATION OF PLATE XII.

Oryza sativa.

1. Normal external appearance of a spikelet of an ordinary variety of rice.
2. Contents of the spikelet of the same during flowering.
3. Contents of the spikelet of the double grain paddy of Bengal. See the number of ovaries.
4. Raw spikelet of an ordinary variety showing one of the empty glumes much elongated.
5. A. Spikelet of an ordinary variety showing an additional empty glume.
   B. Continuation of the additional empty glume from the side of the pedicel.
6. A. Side view of the spikelet of an ordinary variety showing the fusion of the additional empty glume with the normal empty glume.
   B. Diagrammatic representation of same.
7. Spikelet of an ordinary variety showing additional flowering glume and pale which are rudimentary.
8. Another spikelet showing more developed additional flowering glume and pale.
9. Spikelet of an ordinary variety showing the doubling of the flowering glumes. Note the full development and the two awns.
10. Diagrammatic representation of the spikelet in fig. 7 showing free pales and two rudimentary ovaries.

PLAT


Fig. 1.

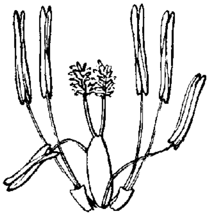
Fig. 2.

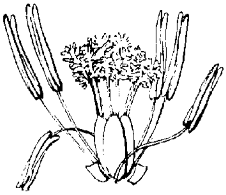
Fig. 3.


Fig. 4.


A B
Fig. 5.

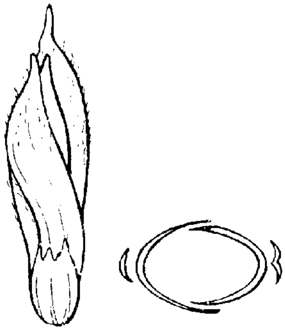
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Fig 6.

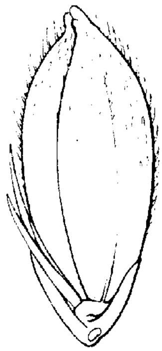


Fig. 7.


Fig. 8.

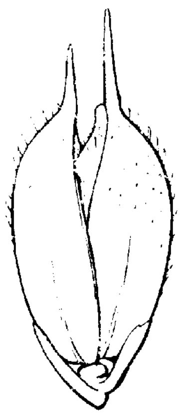


Fig. 9.

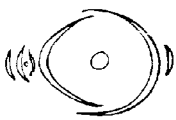


Fig. 10.

ORYZA SATIVA.

to one another. The spikelets here consist of two small empty glumes which stand on the outside of the remaining flowering glume, and glume-like pale, which normally enclose two lodicules, six stamens, and a solitary pistil, with two styles and hairy stigmas. The flowering glume is broader than the pale which it overlaps, an generally bulges out more at the back than the latter. While the flowering glume is five-nerved, the pale is only three-nerved.

The variations occasionally noticed in this variety, as regards the nature, number and position of the glumes or other parts of the spikelet, are as follows :—

1. The empty glumes instead of being small and both o equal size, in rare instances, look very unequal by the elongation of one of them as in Plate XII, fig. 4.

2. Sometimes an additional empty glume is produced on the outside of the normal empty glume. This, however, is a part of the pedicel and not of the spikelet; because it generally remains behind when the spikelet falls off, as in Plate XII, fig. 5. Rarely an additional empty glume is produced by the side of the normal empty glume, and becomes fused with it as in Plate XII, fig. 6.

3. In place of the normal flowering glume, *i.e.*, above the lower empty glume, an extra flowering glume, with or without a pale, may sometimes be produced. The extra flowering glume and pale may be quite rudimentary, or they may be more or less developed, as may be quite rudimentary, or they may be more or less developed, as in Plate XII, figs. 7, 8, and 9. The extra pale may be quite free as in Plate XII, fig. 10, or it may be partly or completely fused back to back with the other pale as in Plate XIII, figs. 1 and 2. When the two pales are completely fused together they appear two-faced as in Plate XIII, fig. 2. The pales are often transformed into two processes, each by splitting. In different instances progressive stages of splitting of the pale can be seen as in Plate XIII, figs. 3, 4, and 5. One of the processes into which a pale splits is sometimes rudimentary or absent. A splitting pale generally carries a more or less developed extra pale inside as in Plate XIII, fig. 6, but this may sometimes be absent. When the united pales are split, two processes are formed as in Plate XIII, fig. 7. Each of these may again split into two and may give rise to three or four processes as in Plate XIII, fig. 8. Sometimes

EXPLANATION OF PLATE XIII.

Oryza sativa.

Fig. 1. A spikelet with the doubling tendency from which one flowering glume is removed to show the partial fusion of the poles.

" 2. A two-faced pale formed by the complete fusion of two pales as seen in profile and in a diagrammatic section.

" 3. A pale split at the tip only.

" 4. Another pale split further down.

" 5. Spikelet showing the pale completely split to the base and carrying a well developed extra pale inside.

" 6. A spikelet opened; the pale is completely split to the base, one of the processes is absent and there is a rudimentary pale inside.

" 7. United pales transformed into two processes, by splitting from a sportive spikelet in an ordinary variety. These processes now stand at right angles to the glumes; there are two pretty well developed ovaries.

8. The two processes are further split into two each. Thus there are four processes in all.

9. A. An organ which may be called half glume half pale, in profile.
B. A normal pale in the same position.

Fig. 1.

Fig. 2.

Fig. 3.

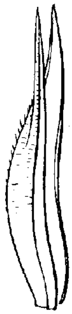


Fig. 4.

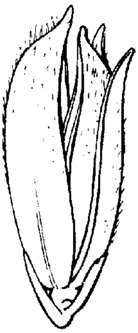


Fig. 5.

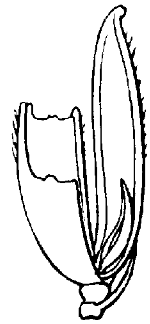


Fig. 6.

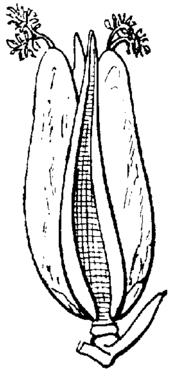


Fig. 7.

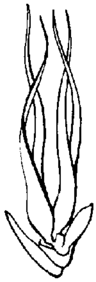
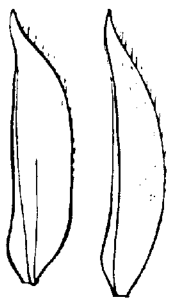


Fig. 8.



A B

Fig. 9.

ORYZA SATIVA

hese processes are much reduced. A flowering glume is sometimes transformed into a pale by the loss of its lateral nerves. Such an organ is sometimes intermediate between a flowering glume and a pale. Because then it shows a lateral nerve as in the flowering glume on one side only and not on the other as in Plate XIII, fig. 9A.

4. The number of stamens may sometimes increase.

5. The number of ovaries may sometimes be doubled as in Plate XIII, fig. 7, accompanied by the doubling of the flowering glume and pale.

6. The number of stigmas may increase without an apparent increase in the ovaries or the flowering glumes. Possibly this is due to the fusion of the ovaries.

Although some of these variations were noticed by me, from time to time, in different plots at Alibag, during the last 6 or 7 years, still, curiously enough, most of them were found to occur in a marked degree in last October in no less than 6 or 7 plots at that station. Most of these plots were grown from seeds obtained from the cultivators. These varieties are generally grown in the salt land along the creeks, though I had grown them in sweet land along with other plots. The following are the names of the varieties which showed the above-mentioned variations :—(1) Morchuka or Dhok ; (2) Morchuka ; (3) Rata ; (4) Kala Rata ; (5) Dodda-Pandya ; (6) Lumba sal ; (7) the double grain paddy of Bengal. Of these the last two are grown in sweet land. No. 6 resembles the "cluster" of the Central Provinces.

In the variety called "Morchuka," out of about 100 plants some eight or ten plants showed a strong tendency in some spikelets to produce additional flowering glumes and pales, and sometimes ovaries also. They also showed the other variations mentioned above. Indeed the tendency to vary was so strong in them that in each plant of the abnormal kind about 10 per cent. of the spikelets showed the sportive nature. In very many instances however these sportive spikelets were sterile, though instances with one well developed grain were not hard to find. Instances with two well developed grains however are rare, though they are not altogether impossible to obtain. Although I cannot vouch for the perfect

purity of the seeds as they were obtained from the cultivators still very probably this sportive tendency does not seem to be due to crossing. In fact, this year I could even see this tendency in several fields in the salt area though to a far less extent. And even then the percentage of abnormal spikelets in the panicles was scarcely two.

From the specimens which I have collected here for sowing and from the accompanying drawings it will be seen that practically every part of the spikelet has a tendency to be doubled. Similarly, all the varieties described above show the tendency to form additional glumes, pales and ovaries. They also show a tendency to form clusters of spikelets where they did not exist before. Thus, they may be said to be more or less overlapping. Whether these overlapping variations are due to some temporary disturbance in the plants, caused by an abnormal season, or they are the beginnings of progressive changes, has yet to be proved.

But at least the large percentage of abnormal spikelets in the panicles found this year, in several plants and from several plots, points towards the latter possibility. It is likely that by these variations nature wants to effect some saving of material or to do more work with the same amount of material. Of course, the production of the additional flowering glumes, pales, stamens, etc., by the double grain paddy might be a retrograde step. But in the other varieties it is not so. In the "cluster" there appears to be some saving of the material of which the axis is made. In the doubling of the flowering glume and pale and of the ovaries, except in the case of the double grain paddy, there seems to be an attempt not only to save the material required for the axis, but also that required for the empty glumes, lodicules and stamens. In some cases in which the pale becomes somewhat reduced, a saving of some of the material required for it must also take place. Thus in all these doubling cases the tendency to vary seems to be for the purpose of producing a type in the end which can give more seed with the same amount of material. Such a type, as we see, is the double grain paddy grown in Bengal.

Would it not be possible, therefore, to make use of the vari-
lity in this particular direction and to help it on to that final
by selection? Or, is it merely a dream to expect so? It is
t possible that it may turn out to be a dream. It may even lead
some interesting results, if properly followed up. My idea is
t by growing a number of generations of the seeds obtained
m the strongly sportive plants, and by selecting from them
tile spikelets with the said tendency, it may be possible in
irse of time to obtain plants resembling the double grain paddy
Bengal. It is true that some variations necessary to show a
mplete change from the ordinary variety to the pure double
in paddy have not yet been observed. Thus, I have not yet
tually come across a case in an ordinary variety of rice in which
ly the ovaries have been doubled without the doubling of the
wering glumes and pales. Doubling of the number of ovaries
companied by reduction and transformation of the glumes and
les can, however, be seen, and it is sufficient ground to hope that
y examining a large number of sportive plants in flower we may
me across the final stage. Unfortunately I could not examine a
fficiently large number of sportive plants in flower this year,
ut next year I hope to follow up that point more successfully.
f we could only get the final stage once, there would be some hope
f being in a position to bring about an experimental evolution
f the double grain paddy from an ordinary variety without the
elp of crossing. I therefore intend to follow up this experiment
or a few years.

SOME FOREIGN INSECT PESTS WHICH WE DO NOT WANT IN INDIA.

BY

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THE danger of introducing new insect pests of different kinds from foreign sources is, nowadays, so well recognized that in most advanced countries, especially where scientific agriculture has made some progress, a system of quarantine is strictly imposed on all articles of import which are likely to bring such pests into the country. Such State action would go a great way in checking the entry of alien insects, especially those which are known to be bad in other countries, and which, if allowed entry, might become a regular menace to agriculture. Well-known examples of unconscious introduction of undesirable animals into new lands are those of the rabbit into Australia, the mungoose into the West Indies, and the sparrow into the United States. When this has been the case even with higher animals much more are the chances favourable to lower animals and especially insects. With their small size, their powers of rapid multiplication, and their varied habits, insects stand very good chances of getting distributed from country to country.

Recognizing the above facts, the Government of India have also moved in the matter recently, and have passed what is called the Pests Act to protect the country from the invasion of foreign insect and fungus pests. Now that the Government have taken action in the matter, I think the present moment is not inopportune to see what the important foreign insect pests are which have

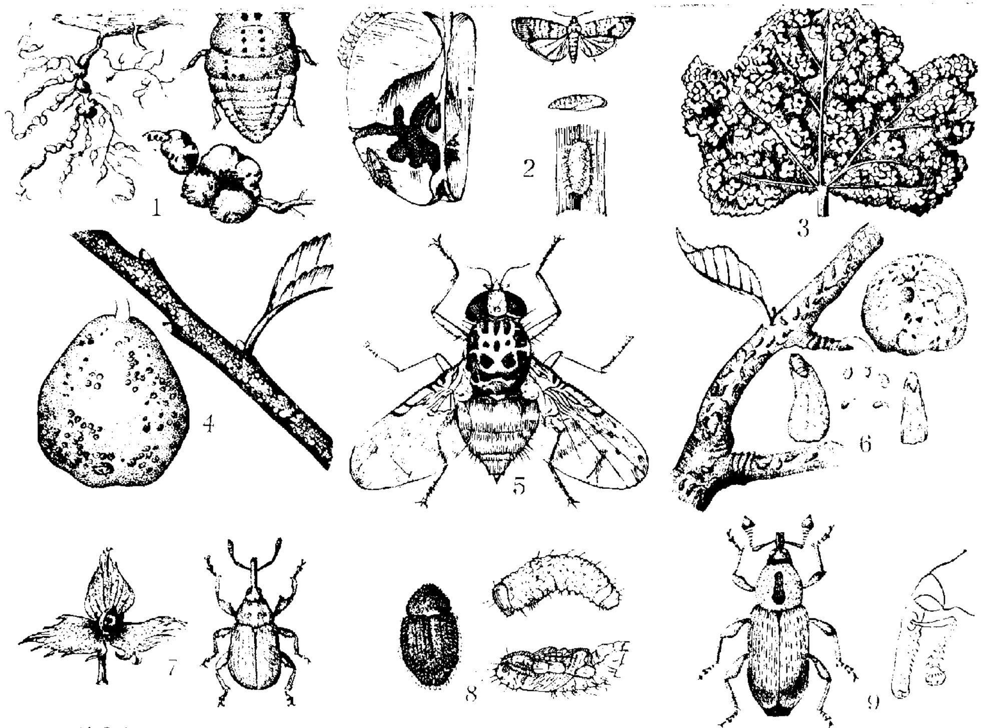
hances of gaining admission into the country, and which have herefore to be carefully watched. In this paper I have attempted to enumerate briefly some of the more important insects of foreign countries which are likely to be introduced into India in some way or other unless proper precautions are adopted to prevent the same.

The geographical position of India might, on the whole, be said to be not so favourable for the introduction of foreign pests as that of most other countries. For, India is more or less isolated, and the countries adjacent to it on the north could hardly be classed as regular agricultural tracts. Besides, there is the mountain wall on the north-west, north, and north-east, and all round below is the sea. This safe position perhaps accounts to a considerable degree for the absence of introduced insect pests. Though a more or less immune condition has been maintained till now, it is very doubtful whether such a safe state of affairs could possibly be kept up in future unless proper measures are adopted. For, in these days of quick and easy transport facilities for all sorts of agricultural products, both by land and sea, there is every likelihood of foreign pests entering the country without our knowledge. The steamships that travel all over the world form the best media of transport in this matter.

At present the countries from which we are likely to get undesirable insects introduced are Ceylon, Java, Philippines, China, Japan, Australia, and New Zealand in the east and south; and now that the Panama canal is open, there is even a chance of South America and West Indies contributing in this direction. On the west we have Africa and the Mediterranean countries of Europe and West Asia. It may, however, be argued—and it is perhaps true to some extent—that insects from temperate regions may not be able to thrive in the tropical climate of India. But this cannot be the case with all insects, as some are able to adapt themselves remarkably to their new homes; nor is it safe to try any experiments in this matter. The well-known saying "Prevention is better than cure" is as much true in this respect as in other affairs. Let us see how and by what means insects are likely to

travel and get entry into new regions. Many agricultural produce when carried from one country to the other for trade or other purposes, are likely to carry with or in them some of the insect pests of the country of origin unless noticed by the exporter and destroyed in time. In many cases the insects are very minute or contained inside agricultural products and thus escape easy detection. And when once they gain entry into some port of a country they have very good chances of finding their way into the interior.

The commonest and most important of agricultural produce in which insects thus travel are chiefly fresh vegetable products, such as bulbs, orchids, sugarcane, sweet potatoes, yams, fruits, seeds, cuttings of ornamental and other plants, moss, peat, tubers and nursery stock of all kinds. Bulbs, orchids, and valuable hot house and ornamental plants are often brought by travellers from one country to another as curiosities without in the least suspecting that they are in many cases bringing in undesirable insect pests with their valuable luggage. It is true that orchids or ornamental plants and their insect pests are not going to affect the agriculture of the country because these are not of any direct economic importance. But what might happen in some cases is that some of the insects on these introduced plants might change their food-plant in the country of adoption, and if this new food-plant happens to be an important field crop, the danger to agriculture becomes quite evident, and this important contingency has always to be borne in mind. Vegetables, roots, tubers and fruits not only travel as cargo, but as necessities for people on board ships. So far as I know, fruits of various kinds, such as apples, oranges, pears, grapes, etc., and nursery stock of these fruit plants are received into India from different Australian ports. Similarly, nursery stock of fruit trees, etc., are also received from Europe chiefly by some of the hill plantations. Sugarcane of new varieties is sometimes got down by Government and private concerns for seed purposes from the West Indies, Java, Mauritius, Hawaii, etc. It is also found that seedsmen and nursery gardeners in the important cities get a good many seeds, bulbs, etc., from other countries, often even by post. These are some of the known media by which we are able to trace the



(1 & 3) Grape-vine Phylloxera; 1 shows root form and 3 the leaf nodules (After Marlatt);
(2) The Codlin Moth-damaged apple and different stages of the moth (*From U. S. A. Bulletin*);
(4) The San Jose Scale on pear (After French);
(5) The Mediterranean Fruit Fly, magnified (from *Insect Life*);
(6) The Oyster Shell Scale on apple (After French);

itry of different exotic pests into the country. In addition to ese, it is possible that insects may be carried in other things hich one would least suspect—some examples of these are packing aterials, bird or cattle food, bird plumage, hunters' trophies, etc. hus the chances of foreign insects getting admission into the untry are easy and many, and hence the need for a more careful d strict quarantine at places of entry.

So far as the existing insect pests of India are concerned, we ve not sufficient records to show which are introduced ones and hich are foreign; but we might name two or three which might e classed as introduced ones, having become naturalized and very ell recognized as pretty bad pests. The potato tuber moth *Phthorimœa operculella*), the diamond-back moth of cabbage and auliflower (*Plutella maculipennis*), and the green bug of coffee *Lecanium viride*) may be given as examples of such. We have no ccurate records as to when and how these gained entry into the ountry, and it is now too late and impossible to drive out these sects which have already acclimatized themselves to their adopted ome.

We will now consider some of the important insects which are ad pests in other countries, and which are likely to get entry into ndia unless both the Government and the importers of agricultural roducts are on the alert and keep out such undesirable insects. t is therefore thought that information on some of the important oreign insects might be of some help at this moment when the Pests Act is just coming into operation.

LEPIDOPTERA (Moths and Butterflies).

In this group of insects the young one or the caterpillar stands a good chance of travelling inside vegetable tissue.

THE CODLIN MOTH (*Carpocapsa pomonella*).

(Plate XIV, fig. 2.)

The most important and the best known of these insects is the "codlin moth" (*Carpocapsa pomonella*). It is the most

destructive of apple insects. The caterpillar bores into the fr
The adult is a beautiful moth with a wing expanse of $\frac{3}{4}$ in.
The annual loss to the United States caused by this insect w
estimated at 16,000,000 dollars in 1909. It is said to be a native
the Mediterranean countries, and is found in England, America
and Australia. There is a record of this insect from Ladak i
Kashmir in the *Ann. M. N. H.* of 1900. But it is probable th
identification was a mistaken one. It might be the "oriental peac
moth" referred to below. However, it is needless to state ho
important it is to keep out this pest from India.

THE ORANGE TORTRIX. (*Tortrix citrana*, Fern.)

Though not as serious as the codlin moth, this small insect
a bad pest of oranges in California and adjacent countries, and stan
a very good chance of travelling in orange fruits.

THE PEACH TWIG BORER. (*Anarsia lineatalla*, Zell.)

This insect is one which is likely to be carried in nursery stock
of stone fruits. It is said to be a native of West Asia and is no
found all over Europe and America. If this insect is already presen
in India, it must be found in the northern fruit tracts. The peculia
habit which this insect has of hibernating in nursery stock help
it in getting widely distributed.

THE ORIENTAL PEACH MOTH. (*Laspeyresia molesta*, Busck.)

This is different from the peach twig borer and affects bot
twigs and fruits. It is a native of Japan and has been introduce
into the United States of America. The adult moth resembles th
codlin moth to some extent, but there are striking structur
differences. The full-grown larva is smaller than that of th
codlin moth. It might also be mistaken for the peach tw
borer, but the differences are clear on closer examination. Th
insect can get itself distributed as larva inside fruit, or as cocoon
on the outside of the plant. Nursery stock may also carry hibe
nating larvæ.

COLEOPTERA (Beetles).

The insects of this group, which are likely to be introduced, are beetles belonging almost wholly to the group of weevils, the grubs which are fleshy and footless and bore into vegetable tissue.

THE COTTON BOLL WEEVIL. (*Anthonomus grandis*, Boh.)
(Plate XIV, fig. 7.)

The most important of exotic beetle pests is the Mexican cotton ll weevil of Texas and adjacent States in the United States. e annual loss to cotton growers from this insect is considerable. e grub bores into the boll and enters the seed. The beetle is in length and has a uniform greyish colour with a prominent out. The pest may be easily carried in seed and in shipments of ginned cotton from one country to another. The loss caused this insect is estimated by Townsend at £ 1,600,000 annually the United States of America.

HE WEST INDIAN SUGARCANE BEETLE. (*Sphenophorus obscurus.*)
(Plate XIV, fig. 9.)

The fleshy grub of this weevil bores into the tissue of sugarne. Seed canes containing the grub can easily spread the st into new tracts. The grub is pale white in colour and footless. e adult insect is about $\frac{3}{4}''$ long and has a dark reddish-brown lour.

HE SMALL SWEET POTATO WEEVIL OF HAWAII. (*Cryptorhynchus batatæ*, Water.)
(Plate XIV, fig. 8.)

This is a small insect similar to the mango seed weevil of India. t is a pretty bad pest in Hawaii and a strict quarantine is imposed n imports of sweet potatoes into California and other American tates. The small pale white grubs bore into the tubers. The nsect should not be confused with the common sweet potato eevil (*Cylasformicarius*) which is blue and red and resembles an nt in form.

The Plum Curculio of the United States of America (*Con-trachelus nenufer*, Herb.) is another important fruit pest of America which might be added to the list of undesirables. The apple blossom weevil (*Anthonomus pomorum*) of Europe has travelled from Europe to America and it is not unlikely that it might come to India also.

DIPTERA (Flies).

Among flies, fruit flies form the chief insects which generally spread from country to country in different kinds of fruits.

THE MEDITERRANEAN FRUIT FLY. (*Ceratitis capitata.*)

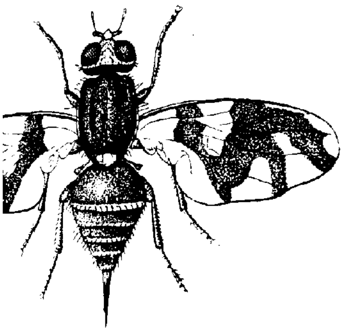
(Plate XIV, fig. 5.)

The most dreaded of fruit pests for which a strict watch has to be kept in India is the notorious Mediterranean fruit fly. It is one of the most serious pests which the orchardists have to fight against. Fortunately it is at present absent in India, though the chances of its entry are great and many. It is found in Europe, South Africa, Australia, New Zealand, and California. It was first noted on oranges from Azores, but now it is found on almost every fruit. The white pointed maggots riddle the fruit pulp and cause considerable damage. We have our native fruit fly (*Dacus cucurbitæ*) which is bad enough on melons of all kinds and on other cucurbits and mangoes, and it would be a very serious matter if the Mediterranean fly gets entry. The travelling public who make pleasure trips might carry fruits to their friends, or for their use, and thus distribute the pest uncon-sciously.

THE QUEENSLAND FRUIT FLY. (*Dacus tryoni.*)

(Plate XV, fig. 2.)

This is another fly attacking fruits in West Australia and doing appreciable damage. This insect has also chances of getting intro-duced. In habits it is exactly like ordinary fruit flies.



\pple Maggot Fly of America, magnified.
(After Slingerland.)

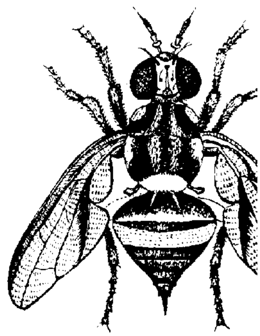
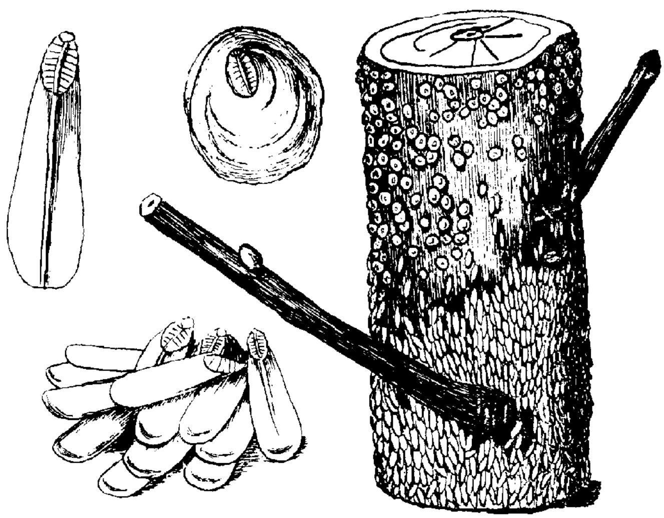


Fig 2. Queensland Fruit Fly, magr
(After Froggatt.)



3. The Japanese Fruit Scale. (*From Portici Bulletin.*)

THE APPLE MAGGOT FLY. (*Rhagoletis pomonella.*)

(Plate XV, fig. 1.)

This bad pest of apple in the United States of America is also important exotic fly pest likely to be introduced.

Another notorious fruit fly is the olive fruit fly of Italy (*Dacus oleæ*).

The most important of all these fly pests is, of course, the Mediterranean fruit fly. The best method is to destroy all maggoty fruits received from foreign sources. This will not only prevent the above-known ones, but would check some species which are not well known, but which might prove serious.

BUGS.

SCALE INSECTS, MEALY BUGS, AND PLANT LICE.

It would be difficult to point to any group of insects whose ravages have been more seriously increased by human interference than the insects mentioned above, especially scale insects and mealy bugs. Of all insects these are easily carried from country to country and some of them adapt themselves remarkably to their new homes. Most of them are minute in size and will stand long journeys: their powers of multiplication are also remarkable. During the course of my studies regarding these insects within the last two or three years, I have observed several scale insects which appear to be introduced. One can very well form an idea of the possibilities of distribution of these insects, when it is known that over thirty species of scale insects have been noted on orchids alone. The following are some of the most important foreign insects of this group.

THE SAN JOSE SCALE. (*Aspidiotus perniciosus.*)

(Plate XIV, fig. 4.)

The first rank amongst scales must be given to the San Jose scale.[1] This may be considered as the foremost of fruit pests in most

[1] *The Agric. Journ. of India*, vol. XII, pt. IV, p. 525.

countries. It is believed to be a native of China; it is now found in South America, United States, Japan, Australia, Hawaii, etc., etc. It has been found attacking pear, apricot, apple, plum, quince, nectarines, etc.; it attacks all parts of the plant—leaves, fruit, trunk, stem, etc. The scales are small and oval and often found in thousands on the surface of fruits.

THE OYSTER SHELL SCALE. (*Mytilaspis pomorum*, Riley.)

(Plate XIV, fig. 6.)

Unlike the San Jose scale, this insect has a more or less mussel shaped, narrow and elongate scale, rounded at one end and tapering towards the other; it is pale brown in colour. It is found as a pest of fruit in America, Australia, New Zealand, Egypt, Algeria, Canada, South America, and Japan. Just like the San Jose scale it attacks fruits of different kinds and gets distributed in fruits and nursery stock. It is one of the very destructive scale insects of the world and has been noted on fruits of various kinds.

THE PURPLE SCALE. (*Mytilaspis citricola*, Pack.)

In general appearance this scale resembles the oyster shell scale, but is darker in colour and more curved than that species. It generally attacks fruits and foliage of all kinds of *Citrus* plants. It has a very wide distribution, being found in Ceylon, Australia, Africa, Europe, and America. This insect is equally liable to be brought into India with oranges, etc., from these countries.

THE COTTONY CUSHION SCALE. (*Icerya purchasi.*)

(Plate XVI, fig. 1.)

This is a well-known and destructive scale insect; in general form it is different from the San Jose, the oyster shell or the purple scale. The body covering in this case is not a hard scale, but a soft cushion made up of white cottony matter, and the cushion arranged in a characteristic manner. The native home of this

PLATE XVI.

Fig. 1. *Icerya purchasi* clustered orange twig, about natural size. (From Essig's *Injurious and Beneficial Insects of California*, Fig. 70).

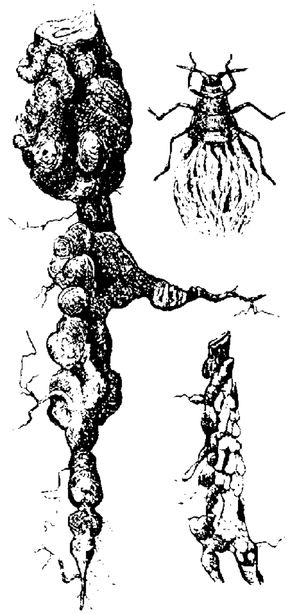


Fig. 2. The Wooly Blight, showing the characteristic nodules caused by the insect. Portion of a root with a colony of the insects (natural size), and a single insect magnified. (After Marlatt.)

sect is said to be Australia, from where it has spread to Africa, rope, North America, South Africa, and the Mediterranean region. is very destructive, especially to orange trees, but has been noted so on a variety of other plants including grape, rose, pomegranate, acia, castor, etc. This insect has recently gained entry into ylon [1], and there is no knowing when we may find it in our midst.

THE LANTANA BUG. (*Orthezia insignis.*)

This mealy bug is another destructive insect which is found most other countries including Ceylon. This has also got the ttony white laminæ. Though it is a beneficial insect when found the weed *Lantana,* it is an undesirable creature, as it may be estructive to other valuable cultivated plants since it has been und to breed on over 30 plants in different countries. This was nce found in a plantation on the Nilgiris, but was promptly estroyed.

There are several other scale insects in foreign countries which ave chances of entering India any time, especially through fruit nd nursery stock. The pineapple scale of Hawaii, *Diaspis bromeliæ*, Ker, is one such important insect. It is not only a pest of pineapple, but has been found on various green house plants in different ountries. It is found in Europe, America, South Africa, West ndies, and Australia. Another likely pest to find its way into the ountry is the Japanese fruit scale (*Diaspis pentagona*) which Plate XV, fig. 3) has already travelled to Europe. I have found the grape and pear scale (*Aspidiotus cydoniæ*), an Australian scale, on nursery stocks of grape and pear in Bangalore got from Australian nurserymen. Within recent years numerous consignments of nursery stock of fruit trees, especially navel oranges, pears, etc., have been got down from Australian nurserymen by several gardeners and private orchardists in South India, and this must have been a very good medium for the distribution of some Australian insect pests.

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[1] *The Agric. Journ. of India,* vol. XII, pt. IV, p. 525.

GRAPE-VINE PHYLLOXERA. (*Phylloxera vastatrix.*)

(Plate XIV, figs. 1 and 3.)

The most serious of grape-vine pests, this insect is found in colonies attacking chiefly the roots, though often found in galls on the foliage also. It is found in Europe and America. The pest is carried on rooted vines, and so becomes easily distributed with nursery stock.

THE WOOLY APHIS OR AMERICAN BLIGHT. (*Schizoneura lanigera*, Haus.)

(Plate XVI, fig. 2.)

This pest, which is very destructive to apples, is found in almost all countries where that plant is cultivated. Its original home is stated to be Europe, from where it appears to have spread all over the world with nursery stock. As early as 1889 Atkinson described in the *Indian Museum Notes* a species of wooly aphis attacking fruit trees on the Nilgiris, and that insect appears to be the one under review; this insect has also been found off and on in the hill districts recently on fruit trees—chiefly on those imported from Europe. It is therefore a case where an insect has already gained some ground in the country. The only thing to do in this case is to prevent its rapid spreading.

Besides the above forms of bugs, species of lace wing bugs (Tingidids) and white flies (Aleurodids) of sorts are also easily transported in nursery stock from one country to another.

Of over twenty insects noted above, the most important ones to be guarded against are the *Codlin moth, the Cotton boll weevil, the Mediterranean fruit fly, the San Jose scale, the Oyster shell scale, the Cottony cushion scale, and the Phylloxera of grape-vine.*

In this paper I have only noted some of the very destructive and well known of foreign insects which have some chances of being introduced into India. It is possible that some or most of them may not be introduced at all, and even if introduced may not thrive; if so, well and good. But a warning note regarding these will not,

think, be inopportune. It is not also unlikely that quite harmless and little known insects of other countries might, when introduced, become bad pests in their new home. Therefore, the safest course to adopt is to make arrangements at ports or places of entry to have all foreign agricultural products of a suspicious nature subjected to a thorough examination, and to destroy or fumigate all insect-infested materials before they are allowed to enter the country.

We, in India, have any number of indigenous insect pests that give us much trouble and bring about considerable loss to the country. We would therefore be multiplying our troubles if we allow alien insects to gain entry into the country. The object of this paper will be very much gained if at least educated cultivators, and those having dealings with foreign countries in agricultural products, realize the danger of allowing foreign pests into the country and do their best to prevent it. If they find it impossible to act effectively in the matter by themselves, they would do well to bring the matter to the notice of the authorities promptly.